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INTERSTATE PLANNING FOR REGIONAL
WATER SUPPLY AND POLLUTION CONTROL

Delaware River Basin Commission

Prepared for:

Environmental Protection Agency

November 1971

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	This report presents the results of a study of the problem of water supply and waste disposal in the three-State, six-county region in which the Tocks Island Reservoir and the Delaware Water Gap National Recreation Area are being developed. Peak summer populations are projected over a 50-year period and utilities systems alternatives which could accommodate such projected growth are presented in the report. Water supplies in the region are seen as adequate to meet future demands, with heavy emphasis on development of groundwater resources. Five alternative sewerage plans, ranging in degree of regionalization from 116 local treatment systems to a single system for the entire region, are outlined including detailed cost estimates. Preservation of water quality in the region is a primary objective of the study.			
Abstractor		Institution		

INTERSTATE PLANNING FOR REGIONAL WATER
SUPPLY AND POLLUTION CONTROL

by

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for

OFFICE OF RESEARCH AND MONITORING
ENVIRONMENTAL PROTECTION AGENCY

Project #16110 FPP (FWPCA WPD-136-01-66)

November 1971

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EPA Review Notice

This report has been reviewed by the Office of Research and Monitoring, EPA, and approved for publication. Approval does not signify that the contents necessarily reflect the views and policies of the Environmental Protection Agency, nor does mention of trade names or commercial products constitute endorsement or recommendation for use.

ABSTRACT

This Foreword, prepared by the Delaware River Basin Commission, and the consultants' report which follows, presents the results of a study of the problem of water supply and waste disposal in the three-State, six-county region in which the Tocks Island Reservoir and the Delaware Water Gap National Recreation Area are being developed.

The consultants' report presents various alternatives for water supply and waste disposal in the 1,000 square mile drainage area of the Tocks Island Reservoir. This region is presently undergoing rapid growth as a result not only of the Federal dam, reservoir, and recreation area projects, but of major new highways, second-home development, land speculation, and the burgeoning recreation industry.

Peak summer populations are projected over a 50-year period and utilities systems alternatives which could accommodate such projected growth are presented in the report. Water supplies in the region are seen as adequate to meet future demands, with heavy emphasis on development of groundwater resources. Five alternative sewerage plans, ranging in degree of regionalization from 116 local treatment systems to a single system for the entire region, are outlined including detailed cost estimates. Preservation of water quality in the region is a primary objective of the study.

This report was submitted in fulfillment of Project Number 16110FFP (FWPCA WPD-136-01-66), under the sponsorship of the Office of Research and Monitoring, Environmental Protection Agency.

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FOREWORD

The following report entitled Tocks Island Region Environmental Study (TIRES) was prepared by the consulting firm of Roy F. Weston, Environmental Scientists and Engineers, West Chester, Pennsylvania, in cooperation with and for the Delaware River Basin Commission and many Federal, State, and local agencies of the parties signatory to the Delaware River Basin Compact. It is a demonstration of interstate, intergovernmental planning for regional water supply and pollution control. The results offer a concrete demonstration that a multiplicity of governmental jurisdictions at varying levels can coordinate efforts to formulate environmental master plans for an intercounty, interstate region undergoing rapid development. Appendix A of the TIRES Report, entitled, Participants And Their Affiliations, lists the various individuals and agencies involved in this study.

Importance of Demonstrating Intergovernmental Cooperation

The Delaware River, and particularly the Tocks Island region, offers an ideal opportunity to demonstrate intergovernmental cooperation. The Tocks Island region portion of the river system includes local, State, interstate, and national interests, all levels of which have responsibilities in the conservation, utilization, development, management, and control of the water and related land resources.

These interests must be coordinated in the solution of a variety of complex technical problems, with full consideration of total watersheds, regional impact, and economies of scale.

TIRES Method of Demonstrating Intergovernmental Cooperation

The Delaware River Basin Commission organized the Tocks Island Region Environmental Study in 1966 under its responsibility as a regional agency of the parties signatory to the Delaware River Basin Compact. Memoranda of Understanding were negotiated with the many Federal, State, interstate, regional, and county agencies concerned with land and water uses, waste disposal, pollution control, natural resources, and environmental health in the region. A copy of the Memorandum of Understanding negotiated and executed with each participant is included at the end of this FOREWORD. These agreements provided for the services of technical personnel from each of the agencies to a total monetary equivalent of over \$200,000, as well as providing a funnel for receipt of invaluable technical and general information related to the study. The cooperation and resources of the various agencies and individuals involved insured that the problems were considered in depth and that all available alternatives were considered adequately.

The plan of operation and the method by which intergovernmental cooperation was effectively demonstrated was through the creation of the TIRES Advisory Committee, composed of top level representatives of each of the 26 participating agencies. Each Advisory Committee member was responsible for liaison between his respective agency and the other participating agencies and for assigning individual specialists from his agency to serve on four TIRES Task Groups, which provided technical expertise to the Delaware River Basin Commission and its consulting engineers.

The four Task Groups were:

- a) Land Use and Population Task Group
- b) Water Supply Task Group
- c) Liquid Waste Disposal Task Group
- d) Solid Waste Disposal Task Group.

Membership on any of the Task Groups was open to any member of the Advisory Committee, and to any person or persons designated by Advisory Committee members. The purposes of the Task Groups were to assist and guide the Commission and its consultant and to effect good communications for the interchange of information between all participants. The Task Groups collected and assembled data, information, references and reports related to water resources, water supply, water demand, and waste disposal and made them available to the consultant through the Delaware River Basin Commission. They also reviewed and submitted comments on interim and preliminary reports prepared by the Commission, its consultants, the Advisory Committee, the other Task Groups, and other cooperating agencies. These inputs to the Study by the participating agencies were a major contribution toward the objectives of the TIRES project.

Success of Demonstrating Intergovernmental Cooperation

It has been shown as a result of the TIRE Study that intergovernmental cooperation in regional water resources planning is not only feasible, it is a requirement in any area or region where a multiplicity of governmental levels is represented, and where jurisdictions and responsibilities overlap.

An important indication of the success of the TIRES cooperative program has been found to be the impact of the report, which has attained stature in subsequent regional planning efforts despite the fact that it is only a feasibility study, and not a detailed plan of action. This is a firm indication that when a program is evolved that represents a unified cooperative effort of all levels of government, its recommendations are more readily accepted than if it originated in a single

agency at any one level of government. It can therefore be stated conclusively that intergovernmental cooperation is an effective and viable tool, and that the concept has been effectively demonstrated by the TIRE Study.

Liquid Wastes and the Regionalization Concept

The concept of regionalization of liquid waste disposal systems in the Tocks Island region is represented dominantly in the TIRES report in the development of the five alternative sewerage schemes. It is appropriate, therefore, to discuss briefly the importance to the TIRES participants of the comprehensive analysis of the regionalization concept as applied to the TIRES project.

Liquid waste disposal in the 1,000 square-mile Tocks Island region is recognized as a major problem. The large area, the scattered population centers, and the topography of the region make it difficult to interconnect the existing population centers with sewers.

However, the present and future uses of the region's water require that their existing high quality be fully protected. The present environment of the Tocks Island region is generally of a high esthetic quality, and the current nationwide interest in the quality of the environment mandates its preservation and enhancement. The special nature of the region, with its central attraction the first national recreation area in the Eastern United States, and the projected enormous investment in the water-oriented recreation facilities and water supplies, justify substantial measures to protect the region's water quality. The factors required consideration of a solution of the waste-water disposal problem that will afford maximum protection of water quality, especially that of the Tocks Island Reservoir. Therefore, a regional system of sewage collection and central treatment with final disposal of the effluent to the Delaware River at a location below the Tocks Island Dam became alternative 5, calling for immediate full regionalization of liquid waste disposal facilities. However, to find a solution that is both acceptable and attainable, the TIRES project investigated various subregional alternatives, providing differing scales of water quality protection, environmental protection, and costs.

The standard advantages of regionalization were found to be apparent and perhaps even more applicable to the Tocks Island region than anywhere else in the Delaware River Basin. As a rule, the larger the treatment facility, the less the cost of construction and operation per capita. More efficient and capable plant operation is attainable in larger facilities since such plants are able to hire qualified supervisory and operating personnel as well as to provide adequate laboratory controls. Many small plants in the Tocks Island region are now op-

erating without these necessities. There is far more flexibility and stability in the operation of a large plant. Since, in addition to the protection of the water quality in the Tocks Island Reservoir, re-use of water will be a factor in the Delaware River downstream of the reservoir, highly sophisticated treatment, which cannot be accomplished with anything less than the most capable maintenance and operation, was considered a necessity for the Tocks Island region.

Additional factors included in the analysis of the regionalization concept in the study area were:

- 1) the cost of water-quality surveillance in the streams and aquifers that must receive and assimilate the effluents from the sewerage systems;
- 2) protection of the esthetic quality of the environment, one of the principle goals of the TIRE Study and its cooperating agencies. Modern, well operated waste water treatment plants can produce effluents that are safe enough from the standpoint of protection of public health, and effluents that will not harm fish or other aquatic life. For example, if effluents are to be discharged into the Tocks Island Reservoir, it can be assumed that they will be treated to whatever degree necessary to protect bathers and boaters using the reservoir, to protect aquatic life in the impoundment, and to protect the potability of water supplies taken from the reservoir directly or from the Delaware River downstream of the dam. However, few would agree that the esthetic quality of a waterway is not somewhat degraded by the discharge into it of sewage, no matter how well treated and diluted. For this reason, the analysis of the regionalization concept included the desirability of limiting the number of streams receiving treated effluents. Obviously, the more regionalized system would give the greatest degree of protection of the esthetic quality of the environment;
- 3) protection of water quality. Beyond the question of esthetics, it was deemed necessary to give special consideration of this future site of a major national recreation area, to the relative degree of protection of the physical, chemical, and biological quality of the waters receiving the effluents from the various sewerage schemes studied. Modern treatment plants can be designed and operated to protect beneficial water uses, however, there is no guarantee that they will be so operated. Mechanical

failures and human errors that are not uncommon in small treatment works, especially in poorly staffed systems--and small plants are generally less effectively staffed than larger facilities. The extent to which treatment facilities fail to meet design effluent standards was found to be an important consideration in the TIRES area;

- 4) degree of dilution. The regionalization concept was analyzed further by consideration of the degree of dilution that will be provided in the receiving waters. Under less regionalized systems, as presented in sewerage alternative 1 in the TIRES report, the tributary streams that would receive the treated effluents are mostly small streams with low flows, especially during the warm summer season when dilution requirements would be greatest. Effluents discharged directly into the Tocks Island Reservoir would have available a virtually unlimited amount of dilution water. However, the mixing characteristics of reservoirs are generally difficult to predict in advance. The actual dilution may be far less than that indicated by the rate of flow of water through Tocks Island Reservoir. Moreover, the waste assimilative capacity of impounded waterways is generally small compared with that of free flowing streams. The flow of the Delaware River below Tocks Island Dam is to be regulated--augmented during periods of natural low flow. This regulation will provide a high degree of dilution of effluents discharged to the main stem of the Delaware below the dam. The factors of dilution and waste-assimilative capacity favored a regionalized approach in the Tocks Island region.

The foregoing, in addition to presenting the importance of detailed consideration of the regionalization concept in the Tocks Island region, reveals the determination of the study group to consider optimum solutions to regional water supply and waste disposal problems, rather than solutions based upon short range objectives at the least cost. If for no other reasons, the objective and need to protect the water quality of the Tocks Island Reservoir and the environment of the surrounding Delaware Water Gap National Recreation Area are considered to be sufficient to warrant development of optimum solutions for the region, and for the public purposes it will eventually serve.

Mathematical Modeling

The Tocks Island Region Environmental Study did not incorporate mathematical optimization techniques in developing the final alternatives for water supply and

waste disposal, although such techniques were considered at the outset and subsequently rejected as not applicable at the time. In addition, it was determined that the detail of system definition and range of system configuration for the study were beyond the scope of mathematical models existing in 1966 when the study was undertaken.

Public Release of the Consultants' Report

Shortly after the consultants' final TIRES report was received by the Delaware River Basin Commission, in mid-1970, a decision was made by the Commission to release the report to the public.

Because the three-volume consultants' report was too large and expensive to distribute widely, a summary was prepared by Commission staff. The summary was included as an attachment to notices of a series of public information meetings in the Tocks Island region and was also made available for general distribution to the press and at other meetings in the region. Arrangements were made for copies of the full TIRES document to be located at accessible locations (schools, town halls, and libraries) throughout the study area for public inspection.

Public information meetings were held at Stroudsburg, Pa., on November 16 and 21, 1970, respectively. The first of these was a formal press conference which resulted in wide coverage of the report and its content in area news media. The second was a presentation at the fifth anniversary meeting of the Tocks Island Regional Advisory Council, a regional seven-county interstate agency concerned with planning in the Tocks Island area.

On December 2, and 8, 1970, additional public information meetings were held at Newton, N.J., and Milford, Pa., respectively.

Although the meetings were publicized in advance, relatively few persons attended.

Finally, during November 1970, copies of the consultants' report were distributed to all participating agencies through the TIRES Advisory Committee, area planning commissions, municipalities, and others concerned with Tocks Island region development.

All copies of the consultants' report distributed to date have included a covering letter as required by the Delaware River Basin Commission, as follows:

"November 2, 1970

"The enclosed report on the Tocks Island Region Environmental Study was prepared for the Delaware River Basin Commission by the consulting firm of Roy F. Weston, Environmental Scientists and Engineers, of West Chester, Pennsylvania. The report presents the results of a three-year study of the problem of water supply and waste disposal in the three-State, six-county region in which the Tocks Island Reservoir and the Delaware Water Gap National Recreation Area are being developed.

"The consultants' report presents various alternatives for water supply and waste disposal in the rapidly growing region. Most important are those alternative sewerage plans designed to protect the quality of water in the region. In particular, the aim of the study and the sewerage alternatives is to prevent degradation of water quality in the Tocks Island Reservoir.

"It is emphasized that the report is by the firm of Roy F. Weston, and the recommendations contained in it are those of the consultants. Although the Delaware River Basin Commission staff and representatives of other Federal, State, and local governmental agencies participated in the three-year study in various ways, none of these agencies has, at this time, endorsed the consultants' report.

"This Commission, in cooperation with other agencies, is currently continuing studies of the sewerage problem of the Tocks Island Region, and it is anticipated that these studies will lead to a selection of the best overall plan for wastewater disposal in the Tocks Island region. These studies should also guide the Commission in its decision on how best to implement the plan selected.

"In the meantime, it is important to note that the Delaware River Basin Commission has not yet reached any decisions concerning an approved Tocks Island regional sewerage plan or its implementation. Reviewers of the consultants' report are invited to submit comments to the Commission on these matters."

Delaware River Basin Commission Plans

It had been the intent of the Delaware River Basin Commission to conduct a public hearing in early 1971 on the inclusion of a regional sewerage system for the Tocks Island region in the Commission's Comprehensive Plan. The hearing was to have been held within the study area, and was to have been limited to the physical problems and prospective solutions. After the hearing, it was the intent of the Commission to consider the testimony and conduct additional staff studies as necessary to develop a recommendation for inclusion of a sewerage plan in the Commission's Comprehensive Plan.

In the intervening period, however, the Tocks Island Reservoir project has been subjected to criticism and additional Federal and Commission studies have been undertaken. It is not anticipated that final sewerage planning will be developed until the outcome of the studies and fate of the Tocks Island Reservoir project is known.

Additional Technical Data

Comments on the Tocks Island Region Environmental Study have been received by the Delaware River Basin Commission from several sources. These comments indicate a need for technical clarification and additional background information on various aspects of the Study.

Determination of Basic Cost Estimation Data. Basic cost estimation data for the treatment plants, interceptor sewers, intracommunity sewers, intracommunity sewers and pumping stations were developed on the basis of the following sources:

Rowan, P. P., Jenkins, K. L., and Howells, D. H. "Estimating Sewage Treatment Plant Operation and Maintenance Costs." Water Pollution Control Federation Journal, Vol. 33, p. 111, 1961.

Logan, John A., Hatfield, W. D., Russell, George S., and Lynn, Walter. "An Analysis of the Economics of Waste Water Treatment." Water Pollution Control Federation Journal, Vol. 34, p. 860, 1962.

Data contained in these references were checked against actual costs of treatment facilities designed by the consultants in the Tocks Island region. The basic cost figures thus determined were adjusted by 30 percent to cover additional (tertiary) treatment, 15 percent was added for construction contingencies, and 20 percent for associated costs. These factors are explained in the TIRES report text.

Unit prices based on prevailing bid prices in the area were used for estimating sewer lines and pumping stations. The prices ranged from \$20 to \$75 per foot for lines and from \$30,000 to \$350,000 for pumping stations.

Discussion of Assumed 95 Percent BOD Removal Rate and Stream Quality Analyses. No stream assimilation studies were performed as part of the Tocks Island Region Environmental Study. The assumption used was that a flat 95 percent biological oxygen demand removal rate is suitable for comparative cost analyses. The basis for this assumption is that all water quality standards established now and in the future by regulatory agencies will have to be met at the time of construc-

tion of new waste-water treatment facilities. It is already a legal requirement that sewage works in the Tocks Island Region Environmental Study area be designed to provide at least secondary treatment (85 percent BOD removal). This is a water quality standard that must be met regardless of any instream water quality considerations. Therefore, stream assimilation studies will serve only as an aid in deciding how much treatment beyond conventional secondary treatment is required to meet instream quality standards and protect specific uses.

Since the TIRE Study period extends to the year 2020, the consultants were therefore required to make a judgment about future standards, not merely those now legally established. It is apparent that future standards will be more stringent than present standards. This judgment leads to a conclusion that tertiary treatment will be required, and that with respect to future organic waste loading, total BOD removal will necessarily be at some level between 85 and 100 percent. Again, as a matter of judgment--and only for purposes of the preliminary feasibility study--it was estimated that over the 50-year period studied, the average treatment requirement with respect to organic waste would be 95 percent BOD removal. In view of the unpredictability of the planning parameters, further refinement is deemed unwarranted at this time.

There are various reasons why more sophisticated stream assimilation studies would not increase the reliability of the TIRES estimates of treatment requirements or cost estimates. There are other judgment factors involved, including land use and population growth, as well as long-range trends in sewerage technology and costs. The margins of error in these factors are much greater than the potential error in the average required treatment level for the 50-year period. For this reason it is clear that nothing would be gained toward improved reliability in estimates of treatment levels and costs from more sophisticated stream assimilation studies. It is emphasized in the report that the absolute values of the estimated treatment levels and costs are not as important as the relative costs of alternative sewerage schemes. The decision to be aided by this preliminary feasibility study is not the exact degree of treatment to be provided, but the degree of regionalization that should be recommended. The specific degree of treatment that should be provided at plants discharging to specific receiving waters is a subject for detailed engineering studies that necessarily must precede financing and construction.

TIRES Eutrophication Analysis. The TIRES consultant conducted studies on effects of waste discharges on the water quality of the future Tocks Island Reservoir and on the natural environment of the Tocks Island region. Specifically, an analysis was performed to ascertain if a significant increase in the eutrophication rate of the Reservoir would be caused by waste discharges from the TIRES area. The consultant concluded that liquid waste from the TIRES area should be treated

to remove approximately 95 percent of the soluble phosphorus in order to control algae, and also that nutrient concentrations from the upstream drainage area must be reduced. The question has been raised whether nitrogen should also have been considered in the consultants' eutrophication analysis.

At the time of the TIRE Study, it was generally accepted that eutrophication could be controlled more easily by limiting the nutrient phosphorus than by limiting nitrogen. It was during this period that the effects of phosphates as a major cause of water pollution were recognized, and the Federal government encourage detergent manufacturers to develop substitutes. The Study reflected this concern by including a cost factor for phosphate removal.

However, nitrates, and other critical elements known to contribute to the nutrient problem, were also considered. It was determined that within the accuracy of estimates necessary for the TIRES regional sewerage feasibility study, the costs for removal would apply equally to either phosphates or nitrates. This cost estimate was utilized in the analysis and selection of a recommended sewerage plan for the region.

Consideration of Package Treatment Plants. The development of alternative wastewater collection and treatment systems for the Tocks Island region included consideration of package treatment plants for on-site use. Such facilities will be necessary in cases where connection to a subregional or regional system is not feasible. In addition, the phasing of wastewater collection and treatment systems has provided generally for the continued use of existing package treatment plants where warranted.

However, experience has shown that package treatment plants may not provide reliable protection to the receiving streams, and that reliability varies directly with the size of treatment plants in general. The greater the size, the less frequent and shorter the periods during which the effluent fails to meet the assumed design effluent quality.

As part of the TIRE Study, the percentage of total time that a plant fails to meet design effluent specifications by five percent or more was estimated. When the percentage below design was related to the plant capacity, it was found that a 50,000 gallon per day plant can be expected to fail to meet the design effluent standards by five percent or more about 45 percent of the time.

Reasons for the relationship between size and reliability for sewage treatment plants were identified as follows:

1. greater frequency of equipment failures in smaller plants;
2. lesser degree of automation in smaller plants;
3. greater deficiencies of training or performance of operating personnel in small plants.

Other contributing factors may be included, such as:

4. greater relative variability of quantity and quality of raw sewage received from smaller service areas; and
5. less degree of laboratory control in smaller plants.

It was concluded, therefore, that the use of package treatment plants should not be recommended for the TIRES area, and that those existing package plants should be under the administrative control of the agency responsible for implementation of a regional sewerage scheme for the region.

Sludge Disposal--Liquid or Solid Waste Problem. Solid waste cost estimates in the TIRES report do not include consideration of sewage treatment plant solids (sludge disposal). The omission was deliberate since costs of handling these sewage treatment plant residues have been included by the consultant in liquid-waste disposal estimates. With the larger plants, such as called for in the more regionalized alternatives, the estimated costs are adequate to provide incineration of sludge, if desirable. For the smaller plants, sludge is proposed to be dewatered and disposed of on land in the vicinity of the treatment facilities.

Presently in the Tocks Island region, sludge is not generally disposed of on lands owned by, or adjacent to, sewage treatment facilities, but is commonly disposed of at sanitary landfills or other lands owned by the municipalities. This is the reason why the present problem of sludge disposal, although minimal (there are only four treatment facilities in the 1,000 square mile region having treatment capacities in excess of 500,000 gallons per day), is considered to be a solid-waste problems.

The projected high growth figures for the study area; the estimated capacities of the various future regional and subregional treatment facilities; the absence of regulations or standards regarding sludge disposal and consideration of the soil limitations of the region related to the inclusion of organic or liquid-wastes in sanitary landfill projects, led to the decision by the consultant to include sludge disposal as part of the liquid waste disposal process. It was felt that administrative control should preferably remain with the agency responsible for management of the regional liquid-waste disposal facilities.

TOCKS ISLAND REGION ENVIRONMENTAL STUDY
MEMORANDUM OF UNDERSTANDING

This memorandum of understanding is entered into by and between the _____ (hereinafter called the "State Agency") and the Delaware River Basin Commission (hereinafter called the "Commission") for the purpose of implementing the project entitled INTERSTATE REGIONAL PLANNING FOR WATER SUPPLY AND WASTE DISPOSAL, hereinafter called the "Project," supported in part by a Demonstration Grant, number WPD-136, from the Research and Training Grant Program, Federal Water Pollution Control Administration. It is mutually agreed as follows:

1. Technical program. --The State Agency and the Commission will cooperate in carrying out the Project as described in the "Application for Water Supply and Pollution Control Demonstration Project Grant" dated February 25, 1966, hereinafter called the "Application," copy of which has been transmitted to the State Agency.

2. State Agency. --The State Agency will:

- (a) assign personnel to take part in the Project as outlined in the application, including the attendance at meetings of the Tocks Island Region Environmental Study Advisory Committee (TIRESAC), participation in the work of the Advisory Committee and task groups, the collection and assembly of data and information related to water resources, water supply, water demand, liquid-waste disposal, and solid-waste disposal in that part of the Tocks Island Region "Study Area," as defined in the application, that is within the State (or Commonwealth) of:

- _____;
- (b) furnish references of reports prepared by the agency related to the Study Area, and will make copies of such reports available for use by the Commission and its consultants;
- (c) assist the Commission and its consultants in locating and contacting other sources of such information in its State;
- (d) obtain, to the extent practicable, additional data and information on that portion of the Study Area in its ju-

isdiction as needed for a feasibility study of water supply, waste-water disposal, and solid-waste disposal for the Study Area, and make such data and information available to the Commission and its consultants;

- (e) review and submit its views and comments on any interim or preliminary reports prepared in connection with the Project by the Commission, its consultants, TIRESAC, the Task Groups, or other cooperating agencies, as requested by the Commission.

3. Commission. --The Executive Director of the Commission will be the Project Director, and the Head of the Program Planning Branch of the Commission will be the Project Coordinator. They will serve, respectively, as Chairman and Vice Chairman of TIRESAC. A member of the Commission staff will serve as secretary of TIRESAC and will prepare minutes of all TIRESAC meetings. The Commission will:

- (a) provide stenographic services required in connection with meetings and other proceedings of TIRESAC;
- (b) maintain records and correspondence pertaining to the Project, and provide access to these materials by the State Agency;
- (c) prepare, or have prepared, and distribute to the TIRESAC member representing the State Agency copies of all TIRESAC-meeting minutes and interim, progress, and special reports prepared in connection with the Project by the Commission staff, TIRESAC, the Task Groups, consultants, or other cooperating agencies;
- (d) prepare or have its consultants prepare any interim, progress, or final report required by the Federal Water Pollution Control Administration;
- (e) prepare and submit allocations, after consultation with the State Agency, for any supplemental grants found necessary to carry out effectively the purposes of the Project.

4. General conditions.--The following general conditions shall apply to all activities of the Commission and the State Agency supported in whole or in part by the Demonstration Project funds:

- (a) the State Agency will comply with all general conditions regarding the grant period, nondiscrimination in employment, patents, publications, and copyrights, as set forth in the Application;
- (b) the State Agency and the Commission staff and all consultants will comply with the requirements of the Delaware River Basin Compact, and particularly Article 15 thereof.

5. Identification of documents.--All reports, maps, and other documents completed by the State Agency as a part of this Project, other than documents prepared exclusively for internal use within the State Agency, shall carry the following notation on the same page (or in the case of maps, in the same block) containing the name of the State Agency:

This project was supported in part by a Demonstration Grant, number WPD-136, from the Research and Training Grant Program, Federal Water Pollution Control Administration.

6. Confidential findings.--Any reports, information, data, etc., given to or prepared or assembled by the State Agency with grant funds which the Commission requests to be kept as confidential shall not be made available to any individual or organization by the State Agency without the prior written approval of the Commission.

7. Information exchange.--Information developed by either Party to this memorandum of understanding under this Project will be made freely available to the other Party for purposes of this Project and for other purposes related to the responsibilities of the other Party. Similarly, information developed by either Party for purposes not directly related to this Project, but information of use to the other Party for purposes of the Project, will be made freely available to the other Party.

8. Term of Project and grant period.--The term of the Project is May 1, 1966, through April 30, 1969. The currently approved grant period is May 1, 1966, through April 30, 1967. All grant funds for any grant period received by the State Agency from the Commission must be for services performed

or expenditures made within the term of the Project and within the approved grant period. No reimbursable services shall be performed or reimbursable expenditures made by the State Agency for the second year or third year of the Project term until the State Agency is notified in writing by the Commission that the grant for the second or third year, respectively, has been approved by the Federal Water Pollution Control Administration.

9. Maximum reimbursement.--The maximum reimbursement by the Commission to the State Agency for expenditures by the State Agency for personnel, equipment, consumable supplies, travel, other expenses, or indirect costs shall not exceed the respective amounts allocated from grant funds for these purposes to the State Agency or modification thereof. Except as modified by written agreement, the maximum total reimbursement by the Commission to the State Agency for expenditures made and services performed for purposes of this Project shall not exceed the total grant funds allocated to the State Agency in the Application or modification thereof.

10. Submission of vouchers.--Vouchers for reimbursable expenditures for purposes other than personal salaries will be submitted after and for three-month periods ending July 31, October 31, January 31, and April 30 in each project year. Vouchers for reimbursable personal salaries may be submitted at the end of each calendar month. Vouchers will be accompanied by appropriate substantiating records, statements, or receipts.

11. Audit of records.--Financial and other records of the Project will be maintained by the Commission at its headquarters for audit by the Federal Water Pollution Control Administration or other Federal agency concerned.

12. Non-interference.--This memorandum of understanding shall not be construed as preventing either Party from undertaking any activity required to fulfill other responsibilities in the Study Area or elsewhere.

In witness thereof, the parties have caused this memorandum to be
executed as of this ____ day of _____, 1966.

Date

Executive Director
Delaware River Basin Commission

Date

(Signature of Official representing
State Agency)

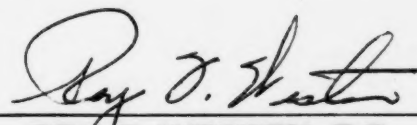
(Title)

(State Agency)

TOCKS ISLAND REGION ENVIRONMENTAL STUDY

**PREPARED FOR
DELAWARE RIVER BASIN COMMISSION**

**APRIL 1970
W.O. 258-03**


**ROY F. WESTON, P.E.
PRESIDENT**



ROY F. WESTON

**ENVIRONMENTAL SCIENTISTS AND ENGINEERS
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SPECIAL ACKNOWLEDGMENTS

In addition to the WESTON staff listed in Appendix A as participants, special acknowledgment should be made of the timely efforts of additional persons in our organization who contributed to the development of final conclusions and production of this report. Their special contribution, requiring special effort during extraordinary hours, is gratefully recognized and appreciated. These persons include:

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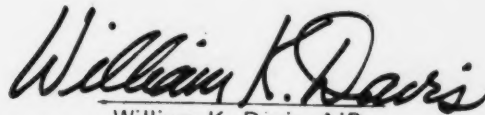
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I. SUMMARY OF FINDINGS AND RECOMMENDATIONS

FINDINGS

General

1. The Tocks Island Region of the Delaware River Basin is experiencing rapid economic development, due in large part to two Federal projects, the Tocks Island Reservoir and the Delaware Water Gap National Recreation Area (DWGNRA), and due, to a lesser extent, to the westward expansion of the highly urbanized areas of New York City and northeastern New Jersey.
2. This economic development will stimulate population growth (both seasonal and permanent), and will result in more intensive use of land for residential, recreational, commercial, and industrial purposes.
3. The recreation facilities resulting from the two Federal projects are expected to handle a recreation load of more than 10 million visitor-days per year, with a peak-day load of about 142,000 visitors.
4. Peak-season population, not including DWGNRA visitors, in the six-county Tocks Island Regional Environmental Study Area (TIRES area)--is expected to increase from about 193,000 in 1970 to almost 926,000 in the year 2020.
5. The expected rapid growth in what is now a predominantly rural area will create new problems and aggravate old problems of water supply and waste disposal. Existing water-supply systems, wastewater systems, and solid-waste disposal systems are grossly inadequate to serve anticipated future demands.
6. Continuous planning and management on an interstate regional basis will be necessary to foresee and prevent problems of water resources and related land use in the Tocks Island Region.

7. For purposes of this study, population (exclusive of DWGNRA visitors), and related water-supply requirements, wastewater volumes, and solid-waste loads for the study area have been projected as follows:

<u>Year</u>	<u>Peak-season population</u>	<u>Water-supply mgd</u>	<u>Waste Quantities</u>	
			<u>Wastewater mgd</u>	<u>Solid wastes pounds/day</u>
1970	193,000	24	19.3	1,061,000
1980	316,000	41	32	-----
1990	475,000	64	47	3,334,000
2000	640,000	90	64	-----
2010	792,000	115	79	-----
2020	926,000	139	93	7,780,000

8. The peak-visitor population in the DWGNRA at full development and the associated water-supply requirements and waste quantities have been projected as follows:

<u>Peak-season population</u>	<u>Water-supply mgd</u>	<u>Waste Quantities</u>	
		<u>Wastewater mgd</u>	<u>Solid wastes tons/year</u>
141,500	3.9	5.7	2,500

9. The plans for water supply, liquid-waste disposal, and solid-waste disposal developed in this study are based in a general way on the "Sketch Plan," prepared by Raymond and May Associates (1966) for the Pennsylvania State Planning Board and for the New Jersey Department of Conservation and Economic Development.
10. The Sketch Plan was updated by the collection of more detailed land use data to show existing developments and trends as of late 1967, but

the basic premises of the original plan were still a valid guide for projecting future land use.

11. The plans developed in the Tocks Island Regional Environmental Study have adequate flexibility for accomodation of developments that depart significantly from the Sketch Plan.
12. Publication of this report constitutes a demonstration of the validity of regional-interstate-interagency planning, which was a primary objective of this project. Without the cooperation and resources of the various agencies and individuals involved in this study, it is unlikely that the problems would have been properly considered or that the available solution approaches would have been adequately developed.
13. This study has shown that sound advance planning can determine a truly comprehensive least-cost system which covers financing and other administrative and auxiliary factors as well as the obvious direct construction and operating costs.
14. A planned system of essential utilities (including water supply and waste disposal) has considerable potential for beneficial influence on area development. With such an approach and the related capability of encouraging or deterring connections, there is a sounder basis for decisions affecting area development and a reinforcement of the likelihood of achieving a least-cost system.

Water supply

1. Water resources are generally abundant and of good quality throughout the Tocks Island Region, and will meet the projected demands if the quality is not degraded by improper disposal of wastewater or solid wastes.

2. Generally, ground water is available in quantities adequate to meet the projected new demands for water in the study area, and it usually can be developed more economically than surface supplies.
3. Existing systems for collection, treatment, and distribution of water will have to be expanded to meet projected demands, but the available water resources will not limit growth within the levels of economic development anticipated for the region.
4. Existing surface-water systems, such as those at Port Jervis, New York, Stroudsburg and East Stroudsburg, Pennsylvania and Newton, New Jersey, can be expanded to meet their projected needs either by further development of surface-water resources or by construction of supplemental ground-water facilities.
5. The corridor area along U. S. Route 209 (in its present location) between Stroudsburg and the boundary of the National Recreation Area will probably have to depend on a surface-water system using water from Tocks Island Reservoir.
6. Although water resources are generally adequate in the region, the paucity of geologic information for most of the region precludes preparation now of detailed plans for development of these resources.
7. Capital costs of source development and of major transmission and treatment facilities for additional community water supplies to meet the projected new demands of the study area through the year 2020 have been estimated as follows (all costs in millions of dollars):

<u>Development Period</u>	<u>Construction Costs</u>	<u>Associated Costs</u>	<u>Total Project Costs</u>
1970 to 1990	57.8	11.6	69.4
1990 to 2020	13.3	2.7	16.0

Wastewater disposal

1. Soils in most of the region are unsuitable for the underground disposal of effluents from septic tanks or other similar wastewater disposal systems, and proliferation of such on-site disposal systems would degrade the quality of the environment and create health hazards.
2. Protection of the region's environmental quality and public health will require public systems for collection and treatment of wastewaters from all parts of the study area except for scattered small residential, recreational, or commercial developments.
3. Alternative plans for serving the projected sewerage needs of the region have been developed to the extent necessary to compare the relative merits of these alternatives with respect to cost and effectiveness.
4. Six alternative sewerage plans were devised and studied, ranging in degree of regionalization from a system of 116 local community collection and treatment works to a single network of interceptor sewers connecting all communities of the study area into a major wastewater treatment plant downstream of Tocks Island Dam.
5. The six wastewater disposal alternatives are as follows:

Alternative I. Multiple Small Systems.--This would have 116 relatively small systems, each serving a local concentration of population, with wastewater collection and treatment capacities ranging from 0.02 to 5.0 million gallons daily (mgd). Alternative I represents the historical approach to sewerage, with minimum regionalization. It would serve a seweraged peak-season population of approximately 673,600 in the year 2020.¹

¹In addition to the DWGNRA visitor population (141,500 estimated peak-day load at full development).

Alternative II. Limited Subregional Systems.--This alternative provides for some regionalization, with consolidation of many of the small local systems into 52 systems ranging in capacity from 0.02 to 24.0 mgd. The total 2020 population served by these systems would be about 752,000 during peak periods.¹

Alternative III. Subregional Systems.--This plan provides for considerably more regionalization than Alternative II; and would consist of six separate collection and treatment systems with capacities ranging from 3.6 to 28.0 mgd.² These systems would serve an aggregate peak-season population of 795,500 in the year 2020.¹

Alternative IV. Regional System from Subregional.--This plan is initially the same as Alternative III, with six subregional systems through the year 2000. After 2000, these subregional systems would be consolidated to form a single collection system that would convey all liquid wastes from sewered communities throughout the study area to a central treatment facility located downstream of Tocks Island Dam.³ This plant, with a capacity of 90 mgd, would serve a 2020 peak-summer population of 840,500.¹

Alternative V. Regional System.--This plan would provide at an earlier date the same system called for after 2000 under Alternative IV. This alternative would also serve a 2020 peak-season population of 840,500.¹

¹In addition the DWGNRA visitor population (141,500 estimate peak-day load at full development).

²In addition to the subregional plants, there would be 15 very minor facilities serving isolated areas. These 15 percent would serve only about one percent of the service population and so are not elaborated upon herein.

³In addition to the subregional and regional plants, there would be 15 very minor facilities serving isolated areas. These 15 facilities would serve only about one percent of the service population and so are not elaborated upon herein.

Alternative VI.--This Alternative was developed by combining I and III. Alternative I would be constructed during the first stage (1970 to 1980) and then abandoned during the second stage (1980-2000); Alternative III would be implemented during the second and third stages. Significant cost disadvantages were obvious, and Alternative VI was not analyzed in further detail.

6. All sewerage alternatives considered would involve high degrees of wastewater treatment (advanced treatment)¹ to protect the quality of streams and other waste-receiving waters.
7. The assumption of advanced treatment was made so that the cost estimated would reflect the probable future requirements of the water quality standards of the Delaware River Basin Commission.
8. In general, the advantages are greater and the per capita costs are lower for the more highly regionalized alternatives.
9. Scattered residential and commercial developments throughout the study area that are beyond economical pipeline distances of a community or regional sewerage system will have to be served by on-site liquid-waste disposal systems. The number of such on-site systems decreases with the degree of regionalization of the public systems.
10. The projected 2020 peak-seasonal population that would be served by on-site and by public systems is as follows:

¹95 percent Biochemical Oxygen Demand and Suspended Solids removals and substantially all phosphates.

<u>Alternative</u>	<u>Population Served by</u>	
	<u>On-Site Systems</u>	<u>Public Systems</u>
I	251,900	673,600
II	173,500	752,000
III	130,000	795,500
IV	85,000	840,500
V	85,000	840,500

11. Capital and average annual costs of treatment facilities, interceptor sewers, and major pumping stations of the liquid waste disposal systems have been estimated and are presented in detail in Appendix M of this report. Alternative I has the lowest capital cost requirement. Alternatives II and III have the next lowest cost and are approximately equal; Alternatives IV and V are the most costly to construct.

The absolute cost differences in annual costs between the Alternatives are less than the capital cost differences, but the same general ranking prevails.

12. Since service populations differ among the Alternatives, average per capita annual costs have also been estimated and are presented in later sections of this report. Alternative III was shown to have the lowest per capita average annual costs.
13. The overall costs of the alternative liquid-waste disposal systems, in terms of present worth (1967 dollars in the year 1970), including the construction costs of intra- and extra-community sewers, interceptors, pumping stations, and treatment plants, as well as operation and maintenance costs for collection, treatment, and disposal of treated wastes

(including those wastes handled by on-site systems), and including those costs associated with water-quality monitoring and surveillance, are estimated as follows:

<u>Alternative</u>	<u>Overall cost (Present Worth -- 1970) millions of dollars</u>
I	332
II	337
III	328
IV	332
V	362

These costs, detailed in later sections of this report, do not include the value of existing sewerage facilities now serving the area, nor do these costs cover the maintenance or replacement of existing facilities that may become worn out or obsolete between the present time and 2020. Such costs are common to all five alternatives and, therefore, need not be considered in the selection of a wastewater disposal system.

14. Present worth sensitivity analyses were performed to ascertain the effects on present-worth cost of varying the basic assumptions and input parameters. Ranges of the following parameters were studied: population projections, interest rate, cost of on-site liquid waste disposal, replacement intervals, and discount periods. Alternative III was shown to have the lowest present-worth cost in seven of the nine sensitivity cases which were analyzed.

15. Each of the Alternatives has high per capita annual costs during the early years of construction and operation. Therefore, special financing¹ will be required in the period 1970 to 1980 in order to begin implementation.
16. By the second and third construction periods (1980 to 2000 and 2000 to 2020), the systems become economically self-sustaining because of the increased populations served.
17. Preliminary studies indicate that the Tocks Island Reservoir will be threatened with an increased eutrophication rate as a result of nutrient loads from the TIRES area and from the upstream drainage area.
18. Nutrient reduction in the wastewaters originating in the TIRES area will significantly reduce the threat, but reduction in the nutrient content of the river upstream is essential for protection of the reservoir.
19. A DARE analysis (Decision Alternative Ratio Evaluation) of Alternatives I through V was conducted to insure that factors other than cost were fully considered in selection of the alternative liquid wastewater disposal system best suited to the TIRES area.
20. Five factors were included in the DARE analysis: Implementation, Adaptability, Reliability, Costs, and Social Benefits.
21. The weightings, or relative importance, of the factors were developed by a panel of 18 members of the staff of ROY F. WESTON for a comparable regional wastewater disposal project.
22. The relative values of each Alternative for each of the five factors were developed by a 10-member panel, which included both members of the previous panel and other ROY F. WESTON personnel.

¹ Financing to cover the difference between actual annual costs and normal use charges paid by those using the system.

23. In addition to the normal practice in DARE analysis of using the average or median values of the factor weightings developed by the panel, weightings based on the 10 percent probability and 90 percent probability values were used in the present DARE analysis, in order to give full consideration to the rather wide differences of judgement among the individual panel members.
24. In all cases, the DARE analysis based on the consensus evaluation of the five alternatives showed that Alternative III was the most favorable.
25. Alternative III would involve a regionalized system which would conform to the recently adopted policy of the Delaware River Basin Commission (DRBC Resolution 68-6), which requires that regional solutions to water pollution problems be used whenever feasible.

Solid waste disposal

1. Although the solid waste disposal phase of this study has been concerned primarily with disposal methods most likely to cause water-quality problems (landfills of one kind or another), some consideration of alternative disposal methods (such as incineration and transportation out of the area) has been necessary to assess the probability of future use of those other methods in relation to water quality protection.
2. The relative costs of incineration, transportation out of the study area, composting, and sanitary landfills, favor the last method of solid waste disposal.
3. Legal and political constraints, in addition to high costs, will probably limit the transportation of solid wastes out of the study area for disposal.
4. In terms of acreage, soil types, and geology, land adequate for disposal of the projected solid waste loads by the sanitary landfill method is

available reasonably near all present and projected concentrations of solid waste generation in the Tocks Island Region.

5. The sanitary landfill method will probably be the most common method of solid waste disposal in the Tocks Island Region.
6. If sanitary landfills are properly designed, operated, and regulated, they can provide satisfactory disposal of solid wastes without detriment to water quality.
7. If all solid wastes generated in the Tocks Island Region are disposed of in sanitary landfills, approximately 11 square miles of land, strategically located within economical haul distances of waste-generation centers, will be needed.
8. The findings of the solid-waste phase of this study, although less definitive than those of the soon-to-be-completed, more comprehensive TIRAC study, justify certain actions, such as land acquisition, now to provide for protection of water resources in the region.

RECOMMENDATIONS

Water supply

1. Develop ground water wherever possible to meet the projected water supply requirements, taking advantage of modern methods of well location, construction, operation, and management to insure optimum use of this relatively abundant resource.
2. As soon as practicable, initiate detailed studies of ground water and potential reservoir sites to provide the information needed by various jurisdictions to design water-supply systems to serve the projected increased demands.
3. Develop a surface water supply, using Tocks Island Reservoir as a source, to serve the corridor area along U. S. Route 209 from Stroudsburg northeast to the DWGNRA limits.
4. Develop and/or expand municipal and county public water supplies needed to serve the growing concentrations of residential, commercial, and industrial water users in the respective jurisdictions.
5. Authorize DRBC to assist in these water-supply developments to the fullest possible extent.

Wastewater disposal

1. Designate the Delaware River Basin Commission (which is the only existing agency in the area with the legal authority and organizational competence to implement waste disposal on an interstate regional basis) as the agency for central administration of any sewerage plan adopted for the TIRES area.
2. Assign to DRBC, as this central agency, responsibility for the design, financing, construction, and operation of the extra-community sewers, major pumping stations, and wastewater treatment plants.

3. Develop suitable contractual arrangements between the central agency and the various communities to cover interception, conveyance, treatment, and ultimate disposal of wastewater.
4. Assign responsibility for intra-community collection of wastewater to the individual communities or to their parent political jurisdictions (e.g. counties).
5. Adopt Alternative III, the subregional approach involving six sub-regional sewerage systems, as the plan for wastewater disposal in the TIRES area.
6. Begin implementation of the selected sewerage plan as soon as it is made a part of the DRBC Comprehensive Plan, to coordinate design, financing, and construction of sewerage facilities with the construction and operation (expected in 1977) of the Tocks Island Reservoir.
7. As soon as practicable, start topographic mapping, right-of-way studies, land acquisition, detailed cost estimating, development of financing and administration methods, and other activities for interceptor sewers and other facilities common to all the alternatives considered.

Solid waste disposal

1. Undertake detailed engineering studies (based on the findings of this study and those of the TIRAC Solid-Waste Management Study) to assess the potential effects of solid-waste disposal on the water resources of the Tocks Island Region, to investigate the feasibility of alternative solid waste disposal methods, and to determine the optimum sites for sanitary landfills and other disposal facilities.
2. Improve the organizational structures, practices, procedures, and regulations of regional, State, and local solid-waste disposal regulatory agencies as necessary to maintain surveillance and control of these disposal methods, for protection of water resources in particular and the quality of the environment in general, as well as for the protection of public health.

3. Because of its special responsibilities in the protection of water resources, the Delaware River Basin Commission should take all necessary steps to insure that solid waste disposal practices conform to the Commission's water-quality standards. These standards should be revised as necessary to protect water resources and water users from the effects of improper methods of solid-waste disposal. The Commission should provide for adequate review and approval of all proposed new sanitary landfills, and for monitoring of existing sanitary landfills, either through its own staff or through other agencies under administrative agreements between these agencies and the Commission.
4. When optimum landfill sites have been located, acquire or otherwise reserve these sites.
5. Incorporate these sites into the Comprehensive Plan of the Delaware River Basin Commission to protect them from encroachment by other noncompatible land uses, and to guide the planning of other land uses.

II. INTRODUCTION

THE PROBLEM

The Congress of the United States has authorized the Tocks Island Dam and Reservoir project and the Delaware Water Gap National Recreation, both located in the Delaware River Basin.

The Tocks Island Dam and Reservoir project was authorized by Congress in 1962. This multi-purpose facility is designed to serve four major purposes: flood control, water supply, recreation, and hydro-electric power generation. The dam, to be located at river mile 217, approximately five miles upstream of the Delaware Water Gap, will create an artificial lake extending 37 miles up the main stem of the Delaware River and 9 miles up Flat Brook, a tributary joining the main stem at river mile 225.3. The reservoir will have over 100 miles of shoreline, an average width of one-half mile, and a maximum width of about one and one-half miles. Pre-construction design work, land acquisition, and actual construction of the dam are the responsibilities of the United States Army Corps of Engineers. The reservoir project was originally scheduled for completion--filled and ready for operation--by 1975.

The Delaware Water Gap National Recreation Area was authorized by Congress in September 1965, and is being developed by the National Park Service. The Recreation Area will encircle Tocks Island Reservoir, and will include the reservoir and approximately 58,000 acres of adjoining lands in New Jersey and Pennsylvania. It will have a capacity for about 150,000 people at any given time, and is expected to provide outdoor recreation for more than ten million visitors annually.

The DWGNRA will include ten visitor-destination sites offering a wide variety of facilities for water sports and other outdoor recreation such as

camping, hiking, and picnicking. It is the first major national recreation area in the eastern United States. Its purpose is to help serve the recreational needs of an anticipated 47-50 million people who will live within 100 miles of the site by the year 2010.

The urbanization and large-scale recreational development, in a rural area, which will result from these projects will cause new problems and aggravate old problems related to water supply and waste disposal. The area involves a multiplicity of governmental jurisdictions. Few have sufficient staff and overall authority for effective handling of such problems. This could lead to the customary piecemeal solutions that have often caused irreparable damage to natural resources in other areas. Few areas are fortunate enough to have in existence the type of governmental structure which provides the organizational and advance-planning responsibilities needed to study such potential problems and able to provide the authority to implement timely solutions. The Delaware River Basin Commission (DRBC) is a unique example of such an organization. Circumstances in the Tocks Island Region of the Delaware River Basin have provided DRBC with the opportunity to undertake an advanced-planning environmental study.

This study, known as the Tocks Island Regional Environmental Study (TIRES), results from DRBC's early recognition of potential problems involving water supply and liquid and solid waste disposal in the three-state, six-county area that will be significantly affected by the creation of the Tocks Island Reservoir and the Delaware Water Gap National Recreation Area (DWGNRA). The problem is to demonstrate how a multiplicity of governmental jurisdictions can coordinate their efforts and cooperate to formulate and adopt an optimum regional environmental master plan.

THE OBJECTIVES

A primary objective of this cooperative study is to demonstrate regional-interstate-interagency planning for prevention of water-supply shortages and water pollution in rapidly developing areas, under the leadership of a new type of regional coordinating agency, The Delaware River Basin Commission. A corollary objective is to develop needed information and to plan for optimum water supply and waste disposal facilities in the specific interstate region influenced by two large Federal projects, the Tocks Island Reservoir and the Delaware Water Gap National Recreation Area.

A final objective of this study is to test the concept of legally protecting a regional water supply and waste disposal plan by making it a part of the official Comprehensive Plan of the Delaware River Basin Commission. The regional plan, developed herein, if adopted by the Delaware River Basin Commission as part of the Basinwide Comprehensive Plan, in accordance with section 13.1 of the Compact, would the legal status necessary for its protection and implementation. Time will necessarily pass before the attainment of this objective can be judged.

The proposed master plan developed as a result of this study provides a degree of flexibility to allow for unexpected developments. To this extent, the study represents an attempt to satisfy the needs for water supply and waste disposal facilities, with neither sanction nor disapproval of what may occur in spite of planned development, but with realistic consideration of the kind of development that is most likely to occur based on sound judgment.

THE APPROACH

In anticipation of the development of water supply and waste disposal problems in the region, the Delaware River Basin Commission organized the three-year Tocks Island Region Environmental Study (TIRES) to demonstrate regional-interstate-interagency planning for water supply and waste disposal in an area developing rapidly under the influence of a large Federal project. In May 1966, the Commission received a demonstration project grant of almost \$250,000 from the Federal Water Pollution Control Administration, United States Department of the Interior, to help finance the study. Under the guidance of the Delaware River Basin Commission, the many Federal, State, interstate, regional, and county agencies concerned with land and water uses, waste disposal, pollution control, natural resources, and environmental health in the region contributed the services of technical personnel. The monetary equivalent of these manpower contributions, totaling \$180,000, increased the total budget to \$430,000 for the three-year study.

Overall coordination of the project has been the responsibility of the Delaware River Basin Commission, acting as a regional agency of the parties signatory to the Delaware River Basin Compact, as provided by Article II of that Compact.

The Commission organized the Tocks Island Region Environmental Study Advisory Committee (TIRESAC), composed of representatives of all participating agencies. Each Advisory Committee member has provided liaison between his respective agency and the other participating agencies. A list of TIRESAC members and their affiliations is presented in Appendix A.

The firm of ROY F. WESTON, Environmental Scientists and Engineers, of West Chester, Pennsylvania, was retained by the Delaware River Basin Commission to assume the major responsibility for assembling data and

information provided by the participating agencies, analyzing the data, preparing reports and preliminary alternative plans, and selecting and developing recommended master regional plans for water supply and waste disposal in the study area.

Four "Task Groups" were organized to assist and guide the consultants and to effect good communications for the interchange of information between participants. Membership in the Task Groups was opened to any member of the Advisory Committee and to any person or persons designated by Committee members. Task Group membership has been modified as the needs of the project dictated. In most cases, the members have been water and planning specialists whose work is directly concerned with development of the Tocks Island Region.

The four Task Groups involved in the study are:

- a. Land Use and Population Task Group,
- b. Water Supply Task Group,
- c. Liquid Waste Disposal Task Group, and
- d. Solid Waste Disposal Task Group.

The Task Group members and their affiliations are also listed in Appendix A.

The approach adopted in this investigation, as well as in this report, should serve as a useful guide for study and planning in other areas of large-scale reservoir and recreational development. It is the hope of the participants that the results of their cooperation will show the way to solution of similar problems in other river basins throughout the nation.

SCOPE OF REPORT

This report is intended to summarize the vast amount of data and analyses compiled during the three-year duration of the project. In order that the pertinent considerations be easily recognized, a series of appendices has been published. It contains basic data, descriptions of analytical procedures, and results of the analyses used to develop and to evaluate the alternative water supply and waste disposal plans presented herein.

In addition to the published appendices, a large amount of open-file information has been compiled in the course of this investigation which are being held by the DRBC as reference information. The reader is referred to this material should he require additional detail not presented in this report.

This report is organized such that general background and introductory information is presented in Sections II and III. The first part of Section IV presents a general description of the methods of analyses used in the investigation. This is followed by summaries of background studies and existing conditions and facilities. The third part of Section IV, Alternative Plans, presents summary descriptions of the various plans which were developed and studied. Section V discusses, compares, and further analyzes the alternatives and presents the recommended courses of action.

III. GENERAL DESCRIPTION OF THE TIRES AREA

TRI-STATE SUBREGION OF DELAWARE RIVER BASIN

Regional setting

The Tocks Island Region Environmental Study area covers approximately 1,010 of the 13,000 square miles of land area drained by the Delaware River and its tributaries. It is located in the eastern upper-central portion of the Delaware River Basin and incorporates within its boundaries parts of the States of New York, New Jersey, and Pennsylvania. The study area includes and surrounds the site of the proposed Tocks Island Reservoir and the Delaware Water Gap National Recreation Area. It is located generally west northwest of New York City, with its closest boundary only 40 miles from mid-Manhattan.

Although the study area is quite close on the east and south to the New York and Philadelphia metropolitan areas, the reservoir site, recreation area, and surrounding study area encompass beautiful and unspoiled lands which appear to have been overlooked by development that has occurred around them, and which remain virtually in their natural state. The area of study is almost completely forested, relatively undeveloped, and offers abundant natural scenic attractions. It is composed of portions of six counties in the three states, each sharing the Delaware River as a part of its boundary. It is a foregone conclusion that with the creation of the Tocks Island Reservoir and the Delaware Water Gap National Recreation Area, significant changes are going to occur in the region covered by the Tocks Island Region Environmental Study. These changes will result from the projected increases in population and associated facilities and from the influx of visitors to the reservoir and National Recreation Area.

Impact area

The reservoir and recreation projects will have a profound effect on the region adjacent to the recreation area. The primary impact will be felt in Pike and Monroe Counties in Pennsylvania, and Sussex and Warren Counties in New Jersey. Orange County, New York, and Northampton County, Pennsylvania, also will be strongly influenced by the combined projects.

Economic demands on these areas were felt even before the Tocks Island project was first authorized, when the idea of a dam on the main stem of the Delaware River was only in the discussion stage. As the proposed project grew in scope to its present major-facility status, these demands developed rapidly. They are expected to continue their upward trend as the population increases and new industrial and recreational growth occurs.

This dynamic and extremely rapid growth potential brought into focus the need for immediate, coordinated, comprehensive regional planning for the entire area surrounding the DWGNRA. The DRBC recognized that a primary concern is the need to plan for the protection and development of water resources in the area surrounding the reservoir itself. The anticipated influx of visitors to the Recreation Area, coupled with large-scale permanent and seasonal development, creates an immediate threat of pollution to the new reservoir and surrounding areas. Existing water supplies are insufficient to satisfy future needs, and many of the existing sewerage systems are either currently taxed beyond their capacity or shortly will be. Unless properly handled, solid wastes will pose a serious threat to water resources and degrade the high aesthetic quality of the region.

TIRES area limits

The area studied is that portion of the Delaware River Basin in Orange County, New York, and in Pike, Monroe, and Northampton Counties,

Pennsylvania, that drains into the Delaware River between the mouth of the Mongaup River and the southern limit of the Delaware Water Gap National Recreation Area, downstream of the Water Gap; and that portion of the Basin in Sussex and Warren Counties, New Jersey above the mouth of Paulins Kill, including the watershed of Paulins Kill.

The area has within its boundaries 51 minor civil divisions in portions of each of the six counties, and has as its border a combination of political boundaries and drainage divides. It was realized by TIRESAC that, ideally, the entire Delaware River watershed above the site of the Tocks Island Dam should be included in any study involving the protection of the waters of the reservoir created by the Tocks Island Dam. However, the magnitude of a study of that size, when considered in light of the limited funds available for the Tocks Island Region Environmental Study made it necessary to define the TIRES area limits to include only the most critical portion of the impact area.

Prior studies

In the course of the TIRES investigation, background information and reports of prior studies were gathered and reviewed. There is a large amount of information, published and unpublished, which must be assimilated for a study of this scope covering such a wide geographical area. As a first step in the assembly of information needed for the study, an extensive bibliography of published and unpublished references on planning, economic-base studies and data, water resources, waste disposal, and related information pertaining to the Tocks Island Region was compiled. The bibliography was issued in preliminary draft form to all participating agencies and was revised continuously as additional references, old and new, were uncovered. The bibliography is presently available as open-file data from DRBC.

Not all the entries in the bibliography had a strong bearing on or a significant relevancy to this study. Therefore, the bibliography was reviewed and pertinent references acquired. The most important prior studies and reports are summarized as follows:

1. Corps of Engineers (1961).--Report of the Comprehensive Survey of Water Resources of the Delaware River Basin (Revised). U. S. Department of the Army, Philadelphia District, Government Printing Office, Washington, D. C., 11 Volumes.

This work, comprising a main report and 10 additional volumes of appendices of supporting information, presents the results of the Federal study of the Water Resources of the Delaware River Basin. Of particular importance to this present investigation was the information for the study area relative to economic base, water use and stream quality, water for irrigational and rural use, recreation resources, hydrology, general geology and ground water, gross and net water needs, project designs and costs, and recreation needs and appraisals.

2. R. R. Nathan Associates (1965).--Impact Analysis-The Delaware Water Gap National Recreation Area: Its Potential influence on Surrounding Communities. Pennsylvania State Planning Board, Harrisburg, Pennsylvania; and New Jersey Division of State and Regional Planning, Trenton, New Jersey.

This study and publication describe the area which will in all probability feel the greatest impact from the Delaware Water Gap National Recreation Area. It presents descriptions of the area as it now exists and attempts to forecast future impact on the area in terms of dollars, facilities and land requirements, taxes, employment, traffic, water pollution control, and broad and generalized population projections.

3. National Park Service (1966).--The Master Plan--Delaware Water Gap National Recreation Area--Pennsylvania-New Jersey. U. S. Department of the Interior, Washington, D. C.

The master plan for the development and layout of all facilities of the DWGNRA is presented, including sizes and locations of all sites, types of recreation, and numbers of visitors each site can handle, by type. It contains a series of maps and a descriptive text concerning the project.

4. Raymond and May Associates (1966).--Preface to Planning--A Sketch Plan for the Tocks Island Region. Pennsylvania State Planning Board, Harrisburg, Pennsylvania; and New Jersey Division of State and Regional Planning, Trenton, New Jersey.

The report presents a generalized view of existing land use, physical features, and a recommended sketch plan for development. It considers population, highways, and utilities in general terms, and indicates the directions in which the development of the area should be guided for optimum development and preservation of recreational and scenic values.

The objective of these studies is to provide an overall guide for optimum land-use development of the impact area, based on the findings of the "Impact Analysis" by Nathan and Associates. The Sketch Plan provides information on projected land use in the impact area upon which the water supply and waste disposal plans prepared in the present study are generally based.

5. Delaware River Basin Commission.--Annual Water Resources Program. Delaware River Basin Commission, Trenton, New Jersey.

The annual Water Resources Program, as developed by the Delaware River Basin Commission, deals with three main areas:

quantity and quality of the water resources of the basin, existing and proposed facilities required to satisfy the varying demands placed upon the water resources, and a presentation of various projects to be undertaken by the Commission. The program considers supplies from and demands placed upon the Delaware River Basin and presents background data and information necessary to balance the supply-demand conditions.

In addition to the above listed reports, the following types of studies and reports were gathered and reviewed for background information:

1. Local, county, and State planning and economic base reports.
2. Available highway studies.
3. Streamflow data: U.S.G.S. Water Supply Papers.
4. County soil surveys: Soil Conservation Service.
5. Soil Conservation Service watershed and soil studies.
6. Geology maps and groundwater studies.
7. Water quality data.
8. Water and sewer system master plans and feasibility reports.
9. Population forecasts.
10. Cost data of facilities.
11. Recreational water demands.
12. Studies in eutrophication and its prevention.

The Impact Analysis, the National Park Service Master Plan, and the Sketch Plan are, in essence, the only prior studies directly concerned with the TIRES area as an entity. A number of efforts are presently underway; these will be discussed in a subsequent section of this report. Because the area has had little study as a unit, a large part of the effort of analyzing background information has necessarily had to deal with correlating and making consistent the numerous individual and unassociated prior studies and reports.

Concurrent programs and related activities

In addition to prior studies and reports, there were several concurrent studies and programs and related activities underway which have had a direct influence and bearing on this study. These related efforts were closely coordinated with TIRES.

A complete listing of related activities is available as open-file data from the DRBC. The most relevant are summarized herein for emphasis:

1. Comprehensive Plan, Delaware River Basin.--The Delaware River Basin Compact requires that the Delaware River Basin Commission prepare, adopt, and amend as necessary a comprehensive plan for the optimum development of the water resources of the entire Basin. The Delaware River Basin Commission adopted Phase I of this Comprehensive Plan in March 1962. The Commission and its staff are engaged continuously in studies leading to modification of the existing plan. The Plan and any amendments, once adopted, are legally protected--no proposed project having a substantial effect on the water resources of the Basin can be undertaken unless the Commission finds that the project would not conflict with or impair the Comprehensive Plan. It is envisioned that the regional water supply and waste disposal plans developed herein by TIRES would be made a part of the Comprehensive Plan. This would give the regional plans legal status and protection that would constrain developments not consistent with those plans.
2. Tocks Island Regional Advisory Council.--Seven counties in the Tocks Island Area have representation on a recently organized Tocks Island Regional Advisory Council (TIRAC). They are Monroe, Northampton, and Pike Counties in Pennsylvania; Sussex

and Warren Counties in New Jersey; and Orange and Sullivan Counties in New York. Among the purposes of this organization are to study region-wide problems, to formulate regional policies, and to prepare plans for the guidance of desirable development of communities and facilities in the Tocks Island Impact Area. The initial program of TIRAC calls for development of plans for orderly development and intelligent use of land surrounding the National Recreation Area. TIRAC will also be concerned with problems of highway relocation, water supply, pollution control, refuse disposal, and fire and police protection. The council members are official representatives of the county governments and are therefore in a position to exercise influence in the legislative and regulatory activities and policies of the local governments directed toward land use and community facilities as required to support any plan developed for the region.

The efforts of TIRAC have been closely followed because its activities should significantly affect the land development pattern of the study area. The Tocks Island Region Environmental Study has maintained close liaison with the TIRAC staff, which is represented in each of the Task Groups.

3. Master Plan for National Recreation Area.--In the Federal Act (Public Law 89-158) authorizing the Delaware Water Gap National Recreation Area, the Secretary of the Interior is directed to adopt and implement a land and water use management plan for the National Recreation Area. The Act (Section 5) states that this plan "...shall include specific provision for, in order of priority--

- “(1) public outdoor recreation benefits;
- “(2) preservation of scenic, scientific, and historic features contributing to public enjoyment;
- “(3) such utilization of natural resources as in the judgment of the Secretary of the Interior is consistent with, and does not significantly impair, public recreation and protection of scenic, scientific, and historic features contributing to public enjoyment.”

The National Park Service of the U. S. Department of the Interior has established a special planning office in the Tocks Island region and has completed the master plan called for in section 5 of Public Law 89-158. Through the medium of representation on the Advisory Committee for TIRES, and through normal planning and consultation with the Delaware River Basin Commission under section 11.1(a) of the Delaware River Basin Compact, the detailed planning of the National Recreation Area as directed by Public Law 89-158 will be fully coordinated with the planning for the larger TIRES area.

4. State and Local Planning.--Each of the counties in the TIRES area has established a planning commission. The commissions are, in varying degrees, generally concerned with formulating the policies and preparing the plans and surveys required for the orderly and beneficial development of the counties. They encourage local community planning and, in some cases, review land subdivisions, aid in the preparation of local master plans, and act to coordinate the efforts of various active groups. The states are also involved with highway planning programs for the DWGNRA impact area.

The status and progress of each of these programs have been considered in this study to promote coordination of the various programs and to assure that the regional water supply and waste disposal master plans take into account, to the extent possible, the most recent plans and goals of the various agencies.

THE STUDY AREA

Drainage basins

To organize the present and future demands for water supply and liquid- and solid-waste disposal, the study area was subdivided into a number of sub-areas. The sub-areas correspond to natural drainage basins. Because the major efforts of the study were directed at water and sewerage planning, the choice of using drainage divisions was obvious. The delineation of major drainage basins and sub-basins considered projected future population centers.

Eight major drainage areas were selected, as follows:

<u>Major Drainage Basin</u>	<u>Area, acres</u>
Pocono Plateau (PO)	105,406
Neversink River (NE)	47,227
Flat Brook (FL)	52,716
Bush Kill (BU)	106,166
Brodhead Creek (BR)	186,970
Cherry Creek (CH)	16,912
Kittatinny (KI)	18,839
Paulins Kill (PA)	112,347
TOTAL	646,583

The eight major basins were subsequently broken down into 24 sub-drainage basins.

The major and sub-drainage basin limits were plotted on appropriate maps. The areas of each of the minor civil divisions (townships, boroughs,

and counties) were measured, and the respective areas in each of the sub-drainage basins were tabulated. Non-usable land areas (based on physical criteria) were removed from the total land area. The results of this analysis are presented in Appendix B.

This analysis and summary provided a convenient means to effect correlation of minor civil division data with drainage basin data. Population, land use, economic base, and other data are generally based on political subdivisions; however, engineering analyses for water and sewerage systems can best be handled on the basis of natural hydrologic units. Therefore, the information in Appendix B provides the vehicle for transfer from one base to the other quickly and consistently.

Political boundaries

Of necessity, some political boundaries were used to define or restrict the study area and the sub-drainage basins. In other cases, the study area boundary actually divides a township or municipality.

As mentioned previously, the TIRES area is composed of all or portions of 51 minor civil divisions, included in the data of Appendix B. Of the approximately 1,010 square miles contained in the study area, 60 square miles are in New York, 290 square miles are in New Jersey, and 660 square miles are in Pennsylvania.

Physiography

Of the three physiographic regions into which the Delaware River Basin naturally divides, two (the Upper and Central regions) are in the TIRES area. The Pennsylvania and New York--or northwestern--portion of the study area is located within the southern Appalachian Plateau province. This area includes a large part of the famous Pocono Mountain resort area and the Stroudsburgs. The land is generally undulating with ridges on the drainage divides reaching maximum elevations of approximately 2,000 feet above mean sea level.

The southeastern portion of the study area is located in the Valley and Ridge province and includes some of the Pennsylvania portion of the study area, near the Delaware Water Gap, and all of the New Jersey portion. This area is characterized by its pattern of parallel ridges running northeast to southwest, of which the most important is the Kittatinny Mountain Ridge of the Shawangau Mountains. The entire study area has been glaciated and is included in what is called the "hard" rock area.

The Delaware River, within the TIRES area, at first flows south-eastward at the point of confluence of the Mongaup River. It forms the boundary between New York and Pennsylvania for a short reach within the study area. At Port Jervis, New York, the River turns abruptly south-westward. At this point, it receives the flows from the Neversink River in New York. From here, for approximately 37 miles downstream, the River flows in the valley between the Shawangau Mountains on the east and the Appalachian Plateau on the west. This stretch is the site to be inundated by the Tocks Island Reservoir. The dam will be located about 100 feet below the southern tip of Tocks Island, an island located on the main stem of the Delaware River about five miles upstream from the Delaware Water Gap. Above the Delaware Water Gap, the river is joined by Bush Kill and Brodhead Creek on the Pennsylvania side, and Flat Brook on the New Jersey side. The land areas drained by these streams and the Paulins Kill, which joins the Delaware downstream of the Delaware Water Gap, comprise the major portion of the Tocks Island Region Environmental Study area.

IV. ALTERNATIVES IN PLANS AND POLICIES

APPROACHES AND INVESTIGATIVE METHODS

The development of master plans for water supply and waste disposal in the TIRES area began with the compilation of comprehensive inventories of existing conditions and facilities to evaluate land use, economic base, highway networks, railroads, surface water resources, geology and ground water resources, soils, and existing water, sewerage, and solid waste disposal systems.

Population growth was projected for each minor civil division and transferred to a drainage area basis. Using these population projections as a base, per capita values were applied to obtain future projections of water supply requirements, sewage flows, and solid waste quantities. In the early stages of the study, two principal planning elements became clear:

1. The magnitude of the task of planning for water supply, sewerage, and solid waste disposal for the TIRES area dictated that the study should concentrate on planning for major facilities only. Detailed study of particular water supply distribution systems or local sewage collection systems would have diverted the study efforts away from the more important regional considerations. Therefore, in the case of sewerage systems, all effort was directed towards the study of major trunk and interceptor lines (including necessary pumping) and treatment facilities. In the water supply investigations, concern was limited to raw water sources, required treatment, and major transmission facilities. Solid waste disposal was studied in terms of projected quantities and disposal considerations relative to ground and surface water contamination and land use.

The exclusion of local water distribution and sewage collection systems from detailed study is consistent with the implementation objectives; these functions should be the responsibility of local government. Interception and treatment, however, can best be managed by a centralized regional agency.

2. There was a significant paucity of information concerning population and land use patterns in the study area. Planning was being performed at several levels of government, but it was either inconsistent in concept, uneven in level of sophistication, in the very early stages of implementation, or not in sufficient detail for use as background information for utilities planning. In order to provide the needed information, extensive examination was made of existing population, road networks, economic base considerations, and land use in the area. It was felt that an understanding of these factors, as they exist today, was essential to forecast the future patterns and impact on regional development.

In view of the above considerations, this investigation had to be limited to broad planning concepts in the development of water supply, sewerage, and solid waste disposal systems. Extensive detailed engineering study and design were not attempted. In certain cases, definitive study was necessary to provide reasonably accurate cost estimates and to evaluate technical feasibility. Construction and operation of each system were evaluated to provide a basis for comparison.

Approaches to the plans

The contents of this report and of the appendices define in detail the various areas of investigation of this study. As an introduction, this section presents a summary of the general methods employed and the approaches taken to formulate the various plans.

Regional planning and population forecasts.--The major planning efforts were concerned with population forecasts and land-use considerations. The population forecasts were derived by use of logistic growth curves for the various minor civil divisions; input included estimates of historical and present (1966) peak populations, rates and time periods of peak growth, existing and future land use, economic considerations, and highway systems. Future populations were initially estimated for the minor civil divisions; these estimates were then apportioned among appropriate drainage areas for water and sewerage planning.

The preliminary Sketch Plan for the area was used as the basis for the land-use investigation. The Sketch Plan was later revised and given clearer definition by employing existing land-use studies and highway proposals. Sufficient detail was then available for water supply and waste disposal planning within the broad scope of the study program.

Population forecasts on the basis either of minor civil divisions or of drainage areas are necessary for a study of this type. However, population densities of developed land will not be uniform throughout a township, borough, county, or a watershed. Population was therefore correlated with future land-use so that population concentrations could be located and utilities provided for the intensive-use areas.

Seasonal as well as year-round residents were considered in the forecasts. The utilities systems were planned and sized to serve the peak (summer) populations to insure adequate protection of the environment.

Water supply systems.--Water supply for the TIRES area was not studied as intensively as liquid waste disposal because of the relative abundance of surface- and ground-water resources. With existing and future land use plans as a basis, future water supply demands were apportioned among areas where populations were expected to concentrate, in order to delineate service areas (see Figure F-1 in Appendix F).

An important consideration in the development of a master plan for water supply for the TIRES area was that most of the region is generally underlain with a ground-water supply of high capacity and good quality. Wherever such conditions exist, economic considerations dictate exploiting ground-water resources in preference to developing surface-water supply systems, if chlorination is the only form of treatment required for the ground water. In the TIRES area, a savings of approximately \$0.35 per thousand gallons can be realized by utilizing ground-water resources instead of surface-water supplies.

Ground-water hydrology and quality were evaluated in a general way for the overall study area. Due to the limited data available, conservative estimates were made of ground-water recharge and aquifer yields. Wherever ground-water supplies appeared adequate, prospective well fields were outlined and cost estimates prepared. If ground water was not available in adequate quantity or quality, surface supplies were recommended.

During the period of this study, detailed ground-water investigations and well-drilling programs (under separate contracts) were performed for the Borough of Delaware Water Gap and for the Hemlock Farms development. In both cases, adequate ground water supplies were developed; the Hemlock Farms well program yielded two wells, each with a capacity of approximately 500 gallons per minute (0.7 mgd). These tangible results provided verification of the assumptions made in the TIRES study relative to ground-water availability.

It must be strongly emphasized, however, that haphazard location, construction, and operation of wells will inhibit accomplishment of the objectives of the water supply plan. Wells should be located in a scientific manner and in accordance with a comprehensive plan. Location, operation, and yields must take cognizance of ground-water use in the entire area.

Where adequate surface water supplies currently exist, they can continue to be used until the demand exceeds the supply, at which time water sources can be augmented by ground-water development.

A comprehensive water supply plan, based primarily on ground-water development, is presented herein; the results of background data and individual basin analyses are presented in the Appendices to justify the decision. The significant cost savings, conservative estimates of recharge and yields, and the concurrent experience with well-drilling programs provide ample basis for recommending extensive ground-water development.

Liquid waste disposal systems.--As discussed in Appendix D, studies of soil conditions indicated that the TIRES area was generally not suitable for on-site liquid waste disposal systems. The proliferation of such systems in built-up areas would result in serious health problems, odors, contamination of surface waters by leaching system overflows, and contamination of ground waters by inadequately treated wastes. Therefore, development of the overall liquid waste disposal system was based on the assumption that local areas which would have population concentrations of greater than two or three persons per acre should be served by public sewerage systems.

Because of the magnitude of the problem of liquid waste disposal for the TIRES area, five alternative sewerage systems were developed and evaluated. These ranged from Alternative I, with 116 wastewater treatment plants, to Alternative V, with a single major wastewater treatment facility downstream of the Tocks Island Dam site. A sixth Alternative, assuming local development (Alternative I) followed by regionalization (Alternative III) was added to complete the comparison.

The alternatives are described in general terms in this section, and in greater detail in Appendix H. Also, these alternatives are compared on the basis of costs, implementation, reliability, adaptability, and social benefits, in Section V of this report.

The various sewerage system alternative plans were prepared by apportioning the drainage basin projected populations and the projected future sewage flows among the areas (service areas) where future populations were expected to concentrate. These service areas are shown in Figure F-1 in Appendix F as recommended future development. Interceptor and major trunk sewers, and wastewater treatment plants were then located on the basis of maximum utilization of gravity flow, access, construction difficulty, and protection of the environment.

To provide maximum protection of the environment and of the Tocks Island Reservoir, it appeared essential that high-level treatment be required at each plant. The cost estimates, based upon BOD and nutrient removals of approximately 95 percent reflect this assumption.

The potential of an increased eutrophication rate of the reservoir caused by upstream and study area waste discharges was analyzed. Its implications are discussed in Section V.

Solid waste disposal systems.--The investigation and study of solid waste disposal systems were conditioned by two important considerations:

1. The basic concern was limited to the prevention of contamination of ground and surface water by improper disposal methods, and
2. A concurrent major study was being conducted by TIRAC that dealt exclusively with solid waste disposal within and beyond the TIRES area. The TIRAC investigation included a complete inventory of existing solid waste disposal practices in the area, projections of future solid waste quantities, and the formulation of future solid waste disposal systems.

Therefore, this study is limited to general predictions of per capita and total daily generation of solid waste, by drainage basin and by county. Gross land area requirements for the 50-year study period were estimated for

landfill and incineration disposal systems within the TIRES area based upon standard compaction estimates.

Unit costs of landfill and incineration were examined, general specifications for site selection were derived for landfill and incineration operations, and administrative procedures (including current land purchases for future need) were evaluated.

The final selection of specific land areas for sanitary landfills or for disposal of incineration residue requires the collection of a significant amount of basic data that is presently unavailable. Although collection of such data was not part of this study, estimates were made of future solid waste quantities by areas, and general criteria were determined for choosing sites and selecting disposal methods. With this background and the work of the TIRAC study, the necessary basic data in the form of precise ground-water levels, aquifer connections, flood plain areas, site accessibility, soil conditions, depths to bedrock, and availability of soil cover, can be collected and analyzed. Through evaluation of these data, final disposal sites and methods can be properly selected.

The program as developed and recommended herein is based on using sanitary landfill for ultimate disposal. It was found that satisfactory landfill areas are close to waste-generating areas and that surface- and ground-water contamination can be avoided. Comparison of landfill cost estimates (\$0.75 to \$4.50 per ton) with incineration estimates (\$6.00 to \$10.00 per ton) indicated significant disposal cost savings with the landfill method. The concept of hauling solid waste out of the area for final disposal could not be justified, largely because the additional haulage cost would result in a less economical program.

It is expected that the potential pollutant interchanges between sanitary landfill and surface- and ground-water contamination can and must be identified. Landfill operations should not be tolerated in any part of the TIRES area where such contamination would result.

SUMMARY OF EXISTING CONDITIONS AND FACILITIES

Existing development pattern

The study of existing land use, economic bases, and transportation is one means of analyzing the emergence and development of an area and of projecting future development patterns. Such studies are presented in Appendix C of this report. Figure C-1 of Appendix C shows the current major land uses in the area.

The relevant conclusions drawn from Appendix C are as follows:

1. Development is currently aggregated in urban centers, villages, and other localized areas.
2. Large tracts of land used for water supply drainage areas, farms, resort areas, game lands, forests, and parks suggests that the TIRES area performs a service/recreation function for nearby metropolitan areas.
3. The open spaces and low-density land use contribute to the natural beauty of the region -- a major asset.
4. The developing land pattern is a result of urbanizing forces and recreational needs in the region.
5. At the present time, the TIRES area may be classified as predominantly rural and non-farm, but on the verge of rapid growth.
6. Employment is highest in manufacturing and retail businesses, but a broad, stable economic base does not exist.
7. Highway travel is the prime means of transportation within the region. The highway network within the TIRES area is not as good as the network which brings people to the area; consequently, local congestion occurs during the summer months.

Surface- and ground-water resources

Detailed investigations were performed to evaluate surface- and ground-water quantity and quality in the TIRES area. The area has abundant supplies of water available for use at reasonable costs.

Surface-water resources were studied by reviewing climatology and by making statistical analyses of surface-water availability from the major streams in the area. Streamflow records were analyzed and draft-storage-frequency tables compiled. Potential reservoir sites were also tabulated. After surface-water quality data were compiled and analyzed, it was found that the surface waters in the study area are of high quality, with dissolved oxygen levels near saturation, pH approximating 7.0, low turbidity, and acceptable hardness and coliform levels.

The analysis of ground-water resources began with a study of the geology of the area and a water-well inventory. Based on the existing well yields and assumed recharge rates, yields per square mile ranging from 50 to 350 gpm, were derived for the various geological formations.

Existing systems

An inventory of existing water supply, sewerage, and solid waste disposal systems was compiled for the TIRES and is presented in Appendix E; the systems are mapped on Figure E-1.

Most of the systems are small and localized, and would make only minor contributions to any regionalization program. However, a few of the sewerage and water supply collection and distribution systems would be significant in regional development. The water and waste disposal systems

for East Stroudsburg, Stroudsburg, Newton, and Port Jervis were found to be of sufficient capacity for consideration as regional facilities. Therefore, comments on their performance and capability are included in this report.

FUTURE CONDITIONS AND NEEDS

Population forecasts

Data on present population, existing and future land uses, economic bases, and transportation systems were used to derive population projections for the TIRES area. The projections were compiled by minor civil division and by drainage basin.

Appendix F presents a detailed discussion of prior studies, the investigative methods used, and the basic data input requirements. The results of the projection technique are also presented and implications discussed.

The inability of existing population projection techniques to reflect the rapid changes in growth expected in the TIRES area led to the development of a new projection method, based on the modification and use of the logistic curve. This curve has the ability to reflect rapid rates of growth, but does not have the undesirable property of allowing these rates to continue unchecked indefinitely. This procedure was used to project peak-season populations by minor civil division and by drainage area.

The results of the analyses are presented in Tables IV-1 and IV-2, which follow. Table IV-1 shows population projections by minor civil division, while Table IV-2 projects population by drainage area.

Utilities requirements

Water supply.--The planning of water supply depends on determinations of water quantities required per person, as well as on overall usage. Per capita consumption in the United States varies widely; recent data indicate 50 to over 200 gallons per person per day. These variations result from such factors as the extent and type of industrial development, size of community, economic and social characteristics of the population, metering of individual connections, and efficiency of distribution systems. Within the study area a

TABLE IV-1

PEAK SEASON POPULATION PROJECTIONS BY
MINOR CIVIL DIVISION¹

<u>County</u>	<u>Township or Borough</u>	<u>1970</u>	<u>1980</u>	<u>1990</u>	<u>2000</u>	<u>2010</u>	<u>2020</u>
Pike	Blooming Grove Twp.	3,100	7,200	15,800	30,600	49,200	65,300
	Delaware Twp.	4,600	7,700	11,600	15,200	17,800	19,300
	Dingman Twp.	2,300	4,400	8,300	14,300	21,800	29,200
	Greene Twp.	3,900	6,200	9,800	14,900	21,900	30,700
	Lehman Twp.	4,500	7,800	12,900	20,100	28,700	37,500
	Matamoras Boro.	3,100	4,100	5,200	6,400	7,600	8,600
	Milford Boro.	2,000	2,800	3,500	4,300	5,000	5,500
	Milford Twp.	1,000	1,200	1,400	1,700	2,000	2,400
	Porter Twp.	900	1,100	1,400	1,700	2,100	2,500
	Shohola Twp.	4,000	8,300	15,400	25,000	34,400	41,200
	Westfall Twp.	2,900	5,600	10,000	16,400	23,700	30,300
	Sub-Total:	32,300	56,400	95,300	150,600	214,200	272,500
Monroe	Barrett Twp.	7,500	10,500	14,600	19,800	26,100	33,400
	Chestnut Hill Twp.	5,800	10,700	17,300	24,000	29,000	32,100
	Coolbaugh Twp.	4,900	8,300	13,100	19,200	25,700	31,600
	E. Stroudsburg Boro.	9,600	11,600	13,800	16,200	18,900	21,700
	Hamilton Twp.	5,100	6,800	8,900	11,700	15,200	19,500
	Jackson Twp.	4,500	9,500	17,400	26,400	33,600	37,700
	M. Smithfield Twp.	9,000	20,500	36,900	51,300	59,400	62,900
	Mt. Pocono Boro.	1,800	2,300	3,000	4,000	5,100	6,700
	Paradise Twp.	5,100	10,100	18,100	27,900	36,800	42,900
	Pocono Twp.	3,800	5,500	8,000	11,300	15,600	20,700
	Price Twp.	900	1,500	2,700	4,700	7,900	12,600
	Ross Twp.	1,900	3,900	7,500	13,000	19,500	25,300
	Smithfield Twp. ²	8,000	14,300	23,800	35,400	46,800	55,800
	Stroud Twp.	10,500	14,200	19,200	25,500	33,300	42,600
	Stroudsburg Boro.	7,300	8,600	10,100	11,800	13,700	15,800
	Tobyhanna Twp.	7,900	16,700	28,400	38,400	44,100	46,700
	Tunkhannock Twp.	1,500	4,800	11,600	18,900	22,700	24,100
	Sub-Total:	95,100	159,800	254,400	359,500	453,400	532,100
Orange	Deerpark	9,200	15,000	19,000	20,900	21,600	21,800
	Greenville	2,200	3,800	5,900	8,700	11,700	14,400
	Mt. Hope	3,900	4,800	5,700	6,700	7,700	8,600
	Port Jervis	10,000	10,400	10,800	11,300	11,700	12,100
	Sub-Total:	25,300	34,000	41,400	47,600	52,700	56,900

TABLE IV-1
(continued)

PEAK SEASON POPULATION PROJECTIONS BY
MINOR CIVIL DIVISION¹

<u>County</u>	<u>Township or Borough</u>	<u>1970</u>	<u>1980</u>	<u>1990</u>	<u>2000</u>	<u>2010</u>	<u>2020</u>
Sussex	Andover Twp.	7,400	22,000	33,500	36,900	37,500	37,700
	Branchville Boro.	1,400	1,900	2,600	3,300	4,100	4,900
	Frankford Twp.	9,000	15,300	22,800	29,300	33,700	36,300
	Fredon Twp.	2,800	6,300	11,900	17,700	21,700	23,600
	Hampton Twp.	7,100	16,200	24,400	28,100	29,300	29,600
	Lafayette Twp.	2,300	4,200	7,300	11,100	14,900	17,800
	Montague Twp.	3,600	8,100	14,700	20,900	24,600	26,200
	Newton	9,400	12,600	15,700	18,500	20,800	22,400
	Sandyston Twp.	6,500	9,800	13,900	18,600	23,300	27,500
	Sparta Twp.	19,300	31,800	46,100	58,900	67,900	73,300
	Stillwater Twp.	14,300	20,800	28,900	37,800	46,500	54,100
	Sub-Total:	83,100	149,000	221,800	281,100	324,300	353,400
Warren	Blairstown Twp.	4,200	7,600	12,200	17,100	21,000	23,400
	Frelinghuysen Twp.	3,400	8,900	15,500	19,100	20,400	20,800
	Hardwick Twp.	2,500	8,500	15,600	18,600	19,300	19,400
	Knowlton Twp.	3,000	5,100	8,200	11,900	15,900	19,300
	Sub-Total:	13,100	30,100	51,500	66,700	76,600	82,900
TOTALS:		248,900	429,300	664,400	905,500	1,121,200	1,297,800

¹Values in this Table represent populations in the entire area of the minor civil division although part of that area (with its population) may actually lie outside of the TIRES area. They do not include DWGNRA visitors.

²Because of its small area and population base, the Borough of Delaware Water Gap is combined with Smithfield Township for purposes of projecting population and demands for water supply and waste disposal.

TABLE IV-2

PEAK SEASON POPULATION PROJECTIONS BY
DRAINAGE BASINS¹

<u>Drainage Basin</u>	<u>1970</u>	<u>1980</u>	<u>1990</u>	<u>2000</u>	<u>2010</u>	<u>2020</u>
PO-1	4,600	7,900	12,400	17,400	22,200	26,300
PO-2	1,300	2,400	4,500	7,500	11,300	14,800
PO-3	2,900	4,300	6,400	9,200	12,100	14,800
PO-4	6,200	9,400	14,200	20,400	27,300	33,400
PO-5	6,100	8,700	10,500	11,300	11,700	11,900
Sub-Total:	<u>21,100</u>	<u>32,700</u>	<u>48,000</u>	<u>65,800</u>	<u>84,600</u>	<u>101,200</u>
NE-1	15,200	20,600	25,900	29,900	32,500	34,100
NE-2	1,100	2,400	4,400	6,300	7,400	7,900
Sub-Total:	<u>16,300</u>	<u>23,000</u>	<u>30,300</u>	<u>36,200</u>	<u>39,900</u>	<u>42,000</u>
FL-1	8,000	12,900	19,500	26,400	32,500	37,300
FL-2	200	400	700	1,000	1,200	1,200
Sub-Total:	<u>8,200</u>	<u>13,300</u>	<u>20,200</u>	<u>27,400</u>	<u>33,700</u>	<u>38,500</u>
BU-1	8,500	16,100	27,500	40,000	51,500	61,300
BU-2	2,000	3,400	5,700	8,500	11,800	14,900
BU-3	2,700	4,700	7,400	10,900	14,600	18,200
Sub-Total:	<u>13,200</u>	<u>24,200</u>	<u>40,600</u>	<u>59,400</u>	<u>77,900</u>	<u>94,400</u>
BR-1	11,700	19,700	31,600	45,200	57,200	66,300
BR-2	10,400	15,000	21,400	29,300	37,500	45,900
BR-3	15,000	24,200	37,700	54,400	71,600	87,400
BR-4	11,400	17,600	26,700	39,200	55,400	75,200
BR-5	16,100	22,900	32,100	42,800	53,700	64,000
BR-6	11,400	19,700	31,500	43,400	52,600	58,900
Sub-Total:	<u>76,000</u>	<u>119,100</u>	<u>181,000</u>	<u>254,300</u>	<u>328,000</u>	<u>397,700</u>
CH-1	3,800	5,100	6,900	9,100	11,800	15,200
Sub-Total:	<u>3,800</u>	<u>5,100</u>	<u>6,900</u>	<u>9,100</u>	<u>11,800</u>	<u>15,200</u>
KI-1	600	1,000	1,600	2,400	3,200	3,900
Sub-Total:	<u>600</u>	<u>1,000</u>	<u>1,600</u>	<u>2,400</u>	<u>3,200</u>	<u>3,900</u>
PA-1	4,600	8,900	14,700	20,000	24,200	27,100
PA-2	9,300	19,000	31,000	39,300	44,700	48,400
PA-3	10,500	17,300	24,600	30,800	36,100	40,500
PA-4	29,800	52,400	76,300	95,000	108,100	116,600
Sub-Total:	<u>54,200</u>	<u>97,600</u>	<u>146,600</u>	<u>185,100</u>	<u>213,100</u>	<u>232,600</u>
TOTALS:	193,400	316,000	475,200	639,700	792,200	925,500

¹These population projections do not include DWGNRA visitors.

wide range of conditions, population densities, seasonal fluctuations, and other characteristics preclude the use of a single value in establishing demand requirements.

Within the confines of the Delaware Water Gap National Recreation Area, estimates of water-supply requirements will be confined to the sites established in the National Park Service Master Plan. These sites include picnic areas, beaches, camping areas, and boating facilities. In addition, major sites will also provide luncheon facilities. Water-supply requirements for these respective areas will vary with the type of use. For each type of activity, average rates for gallons consumed per capita per day (gcd) have been applied as follows:

Picnic Areas	20 gcd
Bathing Areas	10 gcd
Camping Areas	50 gcd
Boating Areas	10 gcd
Luncheon Facilities	4 gcd

These values are based on standards in the Public Health Service publication "Environmental Health Practice in Recreational Areas", and are intended to be average daily figures. Daily peak supply requirements for these types of facilities will be more than twice the projected average values, because demands will remain essentially constant during daylight hours. Water-supply requirements for the park areas during nighttime hours will be very low.

The demand rates presented above are conservative; ie., they are high estimates. These high estimates were used because of the hazards of forecasting demands, and to account for possible future increases in per capita rates. It is assumed that, as in municipal systems, per capita rates will

increase. Furthermore, high estimates will allow future systems to handle possible increases in DWGNRA facilities above those presently considered in the National Park Service Master Plan.

Table IV-3 summarizes water-supply requirements for the National Recreation Area utilized at the projected visitor capacity; Appendix I presents detailed data used to derive the summary information in this table. The total demands were derived by applying the above demand rates to the numbers of people in the various recreational categories as established by the National Park Service. Average daily demand for the DWGNRA is estimated to be 3.9 mgd during the summer months.

Outside the limits of the National Recreation Area, per capita consumption at the present time is approximately 125 gcd during the summer season in the various existing municipal systems. The range is approximately 100 gcd to 200 gcd.

Historically, per capita consumption rates have increased with time as a result of changes in living standards and the advent of such devices as dishwashers, garbage grinders, and automatic lawn sprinklers. The rate of increase has, in many cases, approached a value of 5 percent annually. Therefore, the following criteria were adopted and used in this study to estimate future average daily demands:

<u>Year</u>	<u>Water Supply Requirements</u>
	gcd
1970	125
1980	130
1990	135
2000	140
2010	145
2020	150

TABLE IV-3
SUMMARY OF RECREATION SEASON AVERAGE DAILY
WATER SUPPLY REQUIREMENTS FOR
THE DELAWARE WATER GAP NATIONAL RECREATION AREA¹

<u>Name of Recreation Area Section</u>	<u>N.P.S. Site Numbers Included</u>	<u>Average Daily Demand During Recreation Season</u> mgd
Bush Kill Creek	1-3	0.43
Hill Farm	4-6	0.19
Dingmans Creek	7-9	0.41
Group Camp	10,11	0.04
Silver Spring	12	0.10
Milford	13-15	0.52
Minisink	16-18	0.81
Flat Brook Peninsula	19-23	0.29
Kittatinny	24-30	0.87
Delaware Water Gap	31	<u>0.25</u>
TOTAL		3.91

¹Appendix G contains information used to compile this summary table; values in this table are expressed to the nearest one-hundredth mgd.

Table IV-4 presents the results of the water demand projections by drainage basins as derived by applying the assumed per capita consumption rates to the population projections. Table IV-5 presents the same type of information on the basis of minor civil divisions. The totals are higher in Table IV-5 because the entire political subdivisions are included, although some may lie in part outside the TIRES area.

The values represent expected average water demands during the summer months. These demands would decrease during the non-tourist season in approximate relation to the ratio of summer population to permanent population. The per capita consumption rates include allowances for associated commercial activities and limited industrial usage.

The average figures can vary with time. Peak-day usage could be as high as 1.5 times the average-day usage, while the ratio for peak hourly demand could be as high as 2.5 times the average daily use. Minimum daily use is normally about two-thirds of the average-day usage. Although these ratios are important design considerations, they are primarily problems of storage and layout of the distribution system. Since raw water sources, treatment, and transmission, are the most important concerns, fluctuations in daily demand were not considered in detail.

Liquid waste disposal.--As in the formulation of water supply systems, the design of public sewerage systems relies on design flow criteria, and such criteria have been established by various State Health Departments for use in projecting design sewage flows. Because the three states involved in the present study have established essentially equal criteria for sewage flows, these figures have been applied.

Within the National Recreation Area, a 40 gpd sewage flow quantity was selected from "Environmental Health Practice in Recreation Areas",

TABLE IV-4

PEAK SEASON AVERAGE DAILY
WATER SUPPLY REQUIREMENT PROJECTIONS
BY DRAINAGE BASIN¹

<u>Drainage Basin</u>	<u>1970</u>	<u>1980</u>	<u>1990</u>	<u>2000</u>	<u>2010</u>	<u>2020</u>
PO-1	0.5	1.0	1.7	2.4	3.2	3.9
PO-2	0.2	0.3	0.6	1.1	1.6	2.2
PO-3	0.4	0.6	0.9	1.3	1.8	2.2
PO-4	0.8	1.2	1.9	2.9	4.0	5.0
PO-5	0.8	1.1	1.4	1.6	1.7	1.8
Sub-Total:	<u>2.7</u>	<u>4.2</u>	<u>6.5</u>	<u>9.3</u>	<u>12.3</u>	<u>15.1</u>
NE-1	1.9	2.7	3.5	4.2	4.7	5.1
NE-2	0.3	0.3	0.6	0.9	1.1	1.2
Sub-Total:	<u>2.2</u>	<u>3.0</u>	<u>4.1</u>	<u>5.1</u>	<u>5.8</u>	<u>6.3</u>
FL-1	1.0	1.7	2.6	3.7	4.7	5.6
FL-2	0.1	0.1	0.1	0.1	0.2	0.2
Sub-Total:	<u>1.1</u>	<u>1.8</u>	<u>2.7</u>	<u>3.8</u>	<u>4.9</u>	<u>5.8</u>
BU-1	1.1	2.1	3.7	5.6	7.5	9.2
BU-2	0.2	0.4	0.8	1.2	1.7	2.2
BU-3	0.3	0.6	1.0	1.5	2.1	2.7
Sub-Total:	<u>1.6</u>	<u>3.1</u>	<u>5.5</u>	<u>8.3</u>	<u>11.3</u>	<u>14.1</u>
BR-1	1.5	2.6	4.3	6.3	8.3	9.9
BR-2	1.3	1.9	2.9	4.1	5.4	6.9
BR-3	1.9	3.1	5.1	7.6	10.4	13.1
BR-4	1.4	2.3	3.6	5.5	8.0	11.3
BR-5	2.0	3.0	4.3	6.0	7.8	9.6
BR-6	1.4	2.6	4.3	6.1	7.6	8.8
Sub-Total:	<u>9.5</u>	<u>15.5</u>	<u>24.5</u>	<u>35.6</u>	<u>47.5</u>	<u>59.6</u>
CH-1	0.5	0.7	1.0	1.3	1.7	2.3
Sub-Total:	<u>0.5</u>	<u>0.7</u>	<u>1.0</u>	<u>1.3</u>	<u>1.7</u>	<u>2.3</u>
KI-1	0.1	0.1	0.2	0.3	0.4	0.6
Sub-Total:	<u>0.1</u>	<u>0.1</u>	<u>0.2</u>	<u>0.3</u>	<u>0.4</u>	<u>0.6</u>
PA-1	0.6	1.2	2.0	2.8	3.5	4.1
PA-2	1.2	2.5	4.2	5.5	6.5	7.3
PA-3	1.3	2.2	3.3	4.3	5.2	6.1
PA-4	3.7	6.8	10.3	13.3	15.7	17.5
Sub-Total:	<u>6.8</u>	<u>12.7</u>	<u>19.8</u>	<u>25.9</u>	<u>30.9</u>	<u>35.0</u>
TOTALS:	24.5	41.1	64.3	89.6	114.8	138.8

¹Exclusive of DWGNRA demands. All quantities are in million gallons per day.

TABLE IV-5
PEAK SEASON AVERAGE DAILY
WATER SUPPLY REQUIREMENT PROJECTIONS
BY MINOR CIVIL DIVISION¹

<u>County</u>	<u>Township or Borough</u>	<u>1970</u>	<u>1980</u>	<u>1990</u>	<u>2000</u>	<u>2010</u>	<u>2020</u>
Pike	Blooming Grove Twp.	0.4	0.9	2.1	4.3	7.1	9.8
	Delaware Twp.	0.6	1.0	1.6	2.1	2.6	2.9
	Dingman Twp.	0.3	0.6	1.1	2.0	3.2	4.4
	Greene Twp.	0.5	0.8	1.3	2.1	3.2	4.6
	Lehman Twp.	0.6	1.0	1.7	2.8	4.2	5.6
	Matamoras Boro.	0.4	0.5	0.7	0.9	1.1	1.3
	Milford Boro.	0.3	0.4	0.5	0.6	0.7	0.8
	Milford Twp.	0.1	0.2	0.2	0.2	0.3	0.4
	Porter Twp.	0.1	0.1	0.2	0.2	0.3	0.4
	Shohola Twp.	0.5	1.1	2.1	3.5	5.0	6.2
	Westfall Twp.	0.4	0.7	1.4	2.3	3.4	4.5
	Sub-Total:	4.2	7.3	12.9	21.0	31.1	40.9
Monroe	Barrett Twp.	0.9	1.4	2.0	2.8	3.8	5.0
	Chestnut Hill Twp.	0.7	1.4	2.3	3.4	4.2	4.8
	Coolbaugh Twp.	0.6	1.1	1.8	2.7	3.7	4.7
	E. Stroudsburg Boro.	1.2	1.5	1.9	2.3	2.7	3.3
	Hamilton Twp.	0.6	0.9	1.2	1.6	2.2	2.9
	Jackson Twp.	0.6	1.2	2.4	3.7	4.9	5.7
	M. Smithfield Twp.	1.1	2.7	5.0	7.2	8.6	9.4
	Mt. Pocono Boro.	0.2	0.3	0.4	0.6	0.7	0.9
	Paradise Twp.	0.6	1.3	2.4	3.9	5.3	6.4
	Pocono Twp.	0.5	0.7	1.0	1.6	2.3	3.1
	Price Twp.	0.1	0.2	0.4	0.7	1.1	1.9
	Ross Twp.	0.2	0.5	1.0	1.8	2.8	3.8
	Smithfield Twp.	1.0	1.9	3.2	5.0	6.8	8.4
	Stroud Twp.	1.3	1.9	2.6	3.6	4.8	6.4
	Stroudsburg Boro.	0.9	1.1	1.4	1.7	2.0	2.4
	Tobyhanna Twp.	1.0	2.2	3.8	5.4	6.4	7.0
	Tunkhannock Twp.	0.1	0.6	1.6	2.6	3.3	3.6
	Sub-Total:	11.6	20.9	34.4	50.6	65.6	79.7
Orange	Deerpark	1.2	1.9	2.6	2.9	3.1	3.3
	Greenville	0.3	0.5	0.8	1.2	1.7	2.2
	Mt. Hope	0.5	0.6	0.8	0.9	1.1	1.3
	Port Jervis	1.2	1.3	1.5	1.6	1.7	1.8
	Sub-Total:	3.2	4.3	5.7	6.6	7.6	8.6

TABLE IV-5
(continued)

PEAK SEASON AVERAGE DAILY
WATER SUPPLY REQUIREMENT PROJECTIONS
BY MINOR CIVIL DIVISION¹

<u>County</u>	<u>Township or Borough</u>	<u>1970</u>	<u>1980</u>	<u>1990</u>	<u>2000</u>	<u>2010</u>	<u>2020</u>
Sussex	Andover Twp.	0.9	2.9	4.5	5.2	5.4	5.6
	Branchville Boro.	0.2	0.2	0.3	0.5	0.6	0.7
	Frankford Twp.	1.1	2.0	3.1	4.1	4.9	5.4
	Fredon Twp.	0.3	0.8	1.6	2.5	3.1	3.5
	Hampton Twp.	0.9	2.1	3.3	3.9	4.2	4.4
	Lafayette Twp.	0.3	0.5	1.0	1.6	2.2	2.7
	Montague Twp.	0.4	1.1	2.0	2.9	3.6	3.9
	Newton	1.2	1.6	2.1	2.6	3.0	3.4
	Sandyston Twp.	0.8	1.3	1.9	2.6	3.4	4.1
	Sparta Twp.	2.4	4.1	6.2	8.2	9.8	11.0
	Stillwater Twp.	1.8	2.7	3.9	5.3	6.7	8.1
	Sub-Total:	10.3	19.3	29.9	39.4	46.9	52.8
Warren	Blairstown Twp.	0.5	1.0	1.7	2.4	3.0	3.5
	Frelinghuysen Twp.	0.4	1.2	2.1	2.7	3.0	3.1
	Hardwick Twp.	0.3	1.1	2.1	2.6	2.8	2.9
	Knowlton Twp.	0.4	0.7	1.1	1.7	2.3	2.9
	Sub-Total:	1.6	4.0	7.0	9.4	11.1	12.4
TOTALS:		30.9	55.8	89.9	127.0	162.3	194.4

¹The values in this Table represent water supply requirements for the entire area of the minor civil division even though part of that area (with its associated water supply requirement) may actually lie outside of the TIRES area. DWGNRA demands have been excluded. All quantities are in million gallons per day.

²Because of its small area and population base, the Borough of Delaware Water Gap is combined with Smithfield Township for purposes of projecting population and requirements for water supply and waste disposal.

This value was applied regardless of type of recreation use. Similar to the water demand criteria, the figures employed are conservatively high.

The wastewater flow, based on 40 gcd, to be handled by the treatment plants is assumed to occur during daylight hours. The 40 gcd rate was increased 2.5 times to 100 gcd for interceptor sizing. Because collection systems are not a primary concern, these figures are adequate to develop flow projections. (Peak hydraulic loadings in collection systems would have to be increased by a factor of four to assure proper design).

Table IV-6 summarizes projected average sewage flow quantities for the National Recreation Area utilized at projected visitor capacity. The total sewage flows were derived in the same manner as were the water supply requirements, i.e. by applying the per capita flow criterion to the numbers of persons in the recreational areas.

The average daily sewage flow of 5.66 mgd is 45 percent higher than the projected water supply requirement of 3.91 mgd. This discrepancy was analyzed relative to the approximate length of sewage collection and interceptor lines in the Recreation Area. It was found that the difference was reasonable, based on accepted rates of infiltration of ground water into the sewer lines. Also, such urban water losses as car washing, watering lawns and gardens, and structural washing will not exist in the DWGNRA, and therefore, a high percentage of water supplied will be recovered.

Beyond the limits of the DWGNRA, a per capita sewage flow of 100 gallons per day was used to derive average flows at the treatment plants. This value was increased to 250 gcd for peak hydraulic loadings in interceptor and trunk sewers. Collection system lines would be designed for a hydraulic loading of 400 gcd.

TABLE IV-6
SUMMARY OF RECREATION SEASON AVERAGE DAILY
SEWAGE FLOWS FOR
THE DELAWARE WATER GAP NATIONAL RECREATION AREA¹

<u>Name of Recreation Area Section</u>	<u>N.P.S. Site Numbers Included</u>	<u>Average Daily Sewage Flows</u> mgd
Bush Kill Creek	1-3	0.64
Hill Farm	4-6	0.24
Dingmans Creek	7-9	0.63
Group Camp	10,11	0.54
Silver Spring	12	0.13
Milford	13-15	0.98
Minisink	16-18	1.33
Flat Brook Peninsula	19-23	0.32
Kittatinny	24-30	1.02
Delaware Water Gap	31	<u>0.33</u>
TOTAL:		5.66

¹Appendix G contains information used to compile this summary table; values in this table are to the nearest one-hundredth mgd.

The 100 gcd figure is undoubtedly a high estimate for the early years of the study period even allowing for infiltration; however, it should become increasingly appropriate in future years as per capita water consumption increases.

There is also an apparent discrepancy between per capita water consumption and per capita sewage flows in the area outside DWGNRA. This differential is caused by the fact that the per capita water consumption rates include water lost through transmission and distribution system leaks, evaporation, and water that is not returned to a sewerage system (e.g. lawn sprinkling, car washing, street washing).

Table IV-7 presents the results of the sewage flow projections by drainage basins as derived by applying the assumed 100 gcd criterion to the population forecasts; Table IV-8 presents the same type of information on the basis of political subdivisions. As with the water-supply requirement projections, the totals are higher in Table IV-8 because each minor civil division is considered in its entirety, although part may lie outside the TIRES area.

The quality of sewage flows from the National Recreation Area and from the remainder of the study area cannot be predicted with any degree of accuracy at the present time. Because most of the flow will be domestic-type waste, the overall qualities will likely approximate those qualities prevalent at the present time in municipal systems. These are as follows:

5-day, 20°C BOD:	200 mg/L
Suspended Solids:	250 mg/L

It is assumed that industrial or toxic wastes in the study area may require pretreatment in order to make these types of wastes compatible with municipal-type sewage for combined treatment.

TABLE IV-7

PEAK SEASON AVERAGE DAILY WASTEWATER FLOW
PROJECTIONS BY DRAINAGE BASIN¹

<u>Drainage Basin</u>	<u>1970</u>	<u>1980</u>	<u>1990</u>	<u>2000</u>	<u>2010</u>	<u>2010</u>
PO-1	0.5	0.8	1.2	1.7	2.2	2.8
PO-2	0.1	0.2	0.4	0.8	1.1	1.6
PO-3	0.3	0.4	0.6	0.9	1.2	1.6
PO-4	0.6	0.9	1.4	2.0	2.7	3.6
PO-5	<u>0.6</u>	<u>0.9</u>	<u>1.0</u>	<u>1.1</u>	<u>1.2</u>	<u>1.2</u>
Sub-Total:	2.1	3.2	4.6	6.5	8.4	10.8
NE-1	1.5	2.1	2.6	3.0	3.2	3.4
NE-2	<u>0.1</u>	<u>0.2</u>	<u>0.4</u>	<u>0.6</u>	<u>0.7</u>	<u>0.8</u>
Sub-Total:	1.6	2.3	3.0	3.6	3.9	4.2
FL-1	0.9	1.3	1.9	2.6	3.3	3.7
FL-2	<u>0.0</u>	<u>0.1</u>	<u>0.1</u>	<u>0.1</u>	<u>0.1</u>	<u>0.1</u>
Sub-Total:	0.9	1.4	2.0	2.7	3.4	3.8
BU-1	0.8	1.6	2.7	4.0	5.2	6.1
BU-2	0.2	0.3	0.6	0.9	1.2	1.5
BU-3	<u>0.3</u>	<u>0.5</u>	<u>0.7</u>	<u>1.1</u>	<u>1.5</u>	<u>1.8</u>
Sub-Total:	1.3	2.4	4.0	6.0	7.9	9.4
BR-1	1.2	2.0	3.2	4.5	5.7	6.6
BR-2	1.0	1.5	2.1	2.9	3.7	4.6
BR-3	1.5	2.4	3.8	5.4	7.2	8.7
BR-4	1.1	1.8	2.7	3.9	5.5	7.5
BR-5	1.6	2.3	3.2	4.3	5.4	6.4
BR-6	<u>1.1</u>	<u>2.0</u>	<u>3.2</u>	<u>4.3</u>	<u>5.3</u>	<u>5.9</u>
Sub-Total:	7.5	12.0	18.2	25.3	32.8	39.7
CH-1	<u>0.4</u>	<u>0.5</u>	<u>0.7</u>	<u>0.9</u>	<u>1.2</u>	<u>1.5</u>
Sub-Total:	0.4	0.5	0.7	0.9	1.2	1.5
KI-1	<u>0.1</u>	<u>0.1</u>	<u>0.2</u>	<u>0.2</u>	<u>0.3</u>	<u>0.4</u>
Sub-Total:	0.1	0.1	0.2	0.2	0.3	0.4
PA-1	0.5	0.9	1.5	2.0	2.4	2.7
PA-2	0.9	1.9	3.1	3.9	4.5	4.8
PA-3	1.0	1.7	2.5	3.1	3.6	4.1
PA-4	<u>3.0</u>	<u>5.2</u>	<u>7.6</u>	<u>9.5</u>	<u>10.8</u>	<u>11.7</u>
Sub-Total:	5.4	9.7	14.7	18.5	21.3	23.3
TOTALS:	19.3	31.6	47.4	63.7	79.2	93.1

¹Exclusive of DWGNRA. All quantities in million gallons per day.

TABLE IV-8

PEAK SEASON AVERAGE DAILY WASTEWATER FLOW PROJECTIONS
BY MINOR CIVIL DIVISION¹

County	Township or Borough	1970	1980	1990	2000	2010	2020
Pike	Blooming Grove Twp.	0.3	0.7	1.6	3.1	4.9	6.5
	Delaware Twp.	0.4	0.8	1.2	1.5	1.8	1.9
	Dingman Twp.	0.2	0.4	0.8	1.4	2.2	2.9
	Greene Twp.	0.4	0.6	1.0	1.5	2.2	3.1
	Lehman Twp.	0.5	0.8	1.3	2.0	2.9	3.8
	Matamoras Boro.	0.3	0.4	0.5	0.6	0.8	0.9
	Milford Boro.	0.2	0.3	0.4	0.4	0.5	0.6
	Milford Twp.	0.1	0.1	0.1	0.2	0.2	0.2
	Porter Twp.	0.1	0.1	0.1	0.2	0.2	0.2
	Shohola Twp.	0.4	0.8	1.5	2.5	3.4	4.1
	Westfall Twp.	<u>0.3</u>	<u>0.6</u>	<u>1.0</u>	<u>1.6</u>	<u>2.4</u>	<u>3.0</u>
	Sub-Total:	3.2	5.6	9.5	15.0	21.5	27.2
Monroe	Barrett Twp.	0.7	1.1	1.5	2.0	2.6	3.3
	Chestnut Twp.	0.6	1.1	1.7	2.4	2.9	3.2
	Coolbaugh Twp.	0.5	0.8	1.3	1.9	2.6	3.2
	E. Stroudsburg Boro.	1.0	1.2	1.4	1.6	1.9	2.2
	Hamilton Twp.	0.5	0.7	0.9	1.2	1.5	2.0
	Jackson Twp.	0.5	1.0	1.7	2.6	3.4	3.8
	M. Smithfield Twp.	0.9	2.0	3.7	5.1	5.9	6.3
	Mt. Pocono Boro.	0.2	0.2	0.3	0.4	0.5	0.7
	Paradise Twp.	0.5	1.0	1.8	2.8	3.7	4.3
	Pocono Twp.	0.4	0.6	0.8	1.1	1.6	2.1
	Price Twp.	0.1	0.2	0.3	0.5	0.8	1.3
	Ross Twp.	0.2	0.4	0.8	1.3	2.0	2.5
	Smithfield Twp. ²	0.8	1.4	2.4	3.5	4.7	5.6
	Stroud Twp.	1.0	1.4	1.9	2.5	3.3	4.3
	Stroudsburg Boro.	0.7	0.9	1.0	1.2	1.4	1.6
	Tobyhanna Twp.	0.8	1.7	2.8	3.8	4.4	4.7
	Tunkhannock Twp.	<u>0.2</u>	<u>0.5</u>	<u>1.2</u>	<u>1.9</u>	<u>2.3</u>	<u>2.4</u>
	Sub-Total:	9.6	16.2	25.5	35.8	45.5	53.5
Orange	Deerpark	0.9	1.5	1.9	2.1	2.2	2.2
	Greenville	0.2	0.4	0.6	0.9	1.2	1.4
	Mt. Hope	0.4	0.5	0.6	0.7	0.8	0.9
	Port Jervis	<u>1.0</u>	<u>1.0</u>	<u>1.1</u>	<u>1.1</u>	<u>1.2</u>	<u>1.2</u>
	Sub-Total:	2.5	3.4	4.2	4.8	5.4	5.7

TABLE IV-8
(continued)

PEAK SEASON AVERAGE DAILY WASTEWATER FLOW PROJECTIONS
BY MINOR CIVIL DIVISION¹

<u>County</u>	<u>Township or Borough</u>	<u>1970</u>	<u>1980</u>	<u>1990</u>	<u>2000</u>	<u>2010</u>	<u>2020</u>
Sussex	Andover Twp.	0.7	2.2	3.4	3.7	3.8	3.8
	Branchville Boro.	0.1	0.2	0.3	0.3	0.4	0.5
	Frankford Twp.	0.9	1.5	2.3	2.9	3.4	3.6
	Fredon Twp.	0.3	0.6	1.2	1.8	2.2	2.4
	Hampton Twp.	0.7	1.6	2.4	2.8	2.9	3.0
	Lafayette Twp.	0.2	0.4	0.7	1.1	1.5	1.8
	Montague Twp.	0.4	0.8	1.5	2.0	2.5	2.6
	Newton	0.9	1.3	1.6	1.9	2.1	2.2
	Sandyston Twp.	0.7	1.0	1.4	1.9	2.3	2.7
	Sparta Twp.	1.9	3.2	4.6	5.9	6.8	7.3
	Stillwater Twp.	<u>1.4</u>	<u>2.1</u>	<u>2.9</u>	<u>3.8</u>	<u>4.7</u>	<u>5.4</u>
	Sub-Total:	8.2	14.9	22.3	28.2	32.6	35.3
Warren	Blairstown Twp.	0.4	0.8	1.2	1.7	2.1	2.3
	Frelinghuysen Twp.	0.3	0.9	1.5	1.9	2.0	2.1
	Hardwick Twp.	0.3	0.8	1.6	1.9	1.9	1.9
	Knowlton Twp.	<u>0.3</u>	<u>0.5</u>	<u>0.8</u>	<u>1.2</u>	<u>1.6</u>	<u>1.9</u>
	Sub-Total:	1.3	3.0	5.1	6.7	7.6	8.2
TOTALS:		24.8	43.1	66.6	90.5	112.6	129.9

¹The values in this Table represent wastewater flows for the entire area of the minor civil division even though part of that area (with its associated wastewater flow) may actually lie outside of the TIRES area. DWGNRA excluded. All quantities in million gallons per day.

²Because of its small area and population base, the Borough of Delaware Water Gap is combined with Smithfield Township for purposes of projecting population and demands for water supply and waste disposal.

Solid waste disposal.--Numerous studies have attempted to define the per capita generation of solid wastes in the United States. Estimates of current rate of generation range from 3 to 4-1/2 pounds per person per day (ppd). The differences in approach used by investigators, the lack of accurate community records, and the changing character of the waste produced have a bearing on the reliability of the published data.

All investigators, however, agree that during the past decade the quantity of solid waste materials requiring disposal has been increasing at a rate of approximately one percent per year. Even a cursory look at present day modes of packaging frozen foods and at the proliferation of aerosol cans and non-returnable bottles clearly supports the belief that, without regulation, the trend will continue to increase.

For the purpose of estimating the solid waste accumulation in the TIRES area, an attempt has been made to select representative figures for the rate of waste generated per capita. The figures used for 1970, 1990, and 2020 daily per capita waste generation are 4.5 pounds, 5.5 pounds and 6.4 pounds, respectively. Increase in generation should not continue at as high a growth rate as in the recent past. Rate increases basically result from current packaging practices and convenience products, and it is expected that these practices will ultimately be regulated to prevent the large increase currently being reflected in waste generation.

Assumptions must also be made concerning the production of waste from commercial and other activities in the TIRES area, and concerning the quantity of material which will remain in the area from the transient visitors. Very few studies have been conducted to develop a relationship between total population and commercial activities in a community. Those that have been performed indicate per capita quantities of approximately one pound

per person per day of commercial waste for communities ranging from 80,000 to 200,000 persons; in this study, the one pound rate was applied for 1970 and increased to two pounds by the year 2020.

The criterion used herein relative to solid waste generation by visitors is based upon the assumption that the major impact will be felt in picnic grounds and restaurants. An assigned factor of two pounds per person per day has been used; this represents less than 50 percent of the waste generated in homes.

Table IV-9 summarizes the per capita solid waste production criteria used herein; Tables IV-10 and IV-11 present projected peak daily solid waste loads for 1970, 1990, and 2000. For the DWGNRA, assuming 10,000,000 visitor-days per year, solid waste requiring disposal will approximate 9,000 tons per year.

The implications of 10,000,000 visitor-days at the DWGNRA during the peak season and of the influx of temporary summer residents are readily apparent with respect to their effect on solid waste disposal systems. The capability of a landfill site or incinerator must be established to accommodate the permanent residents during most of the year and also be capable of increasing its capacity during the peak season. The relationship between the permanent residents' requirements and peak requirements (as presented in the earlier discussion of population forecasts) indicates that the basic capacity for disposal of solid waste from the permanent residents must be capable of being increased by 30 to 50 percent during the peak season. Such a requirement does not place an unreasonable burden on either a landfill site or an incinerator. If incinerator capacity is selected to handle the permanent residents' requirements for an 8-hour day, the same facility could handle the peak season by adding an additional daily 8-hour period to the operation.

TABLE IV-9
PER CAPITA SOLID WASTE
GENERATION CRITERIA
in
Pounds per Person per Day

<u>Year</u>	<u>Year-Round and Summer Resident Population</u>	<u>Commercial Equivalent</u>	<u>Total Population plus Commercial Contribution</u>	<u>DWGNRA Visitors</u>
1970	4.5	1.0	5.5	-----
1990	5.5	1.5	7.0	2.0
2020	6.4	2.0	8.4	2.0

TABLE IV-10
PEAK SEASON AVERAGE DAILY QUANTITIES OF SOLID
WASTE GENERATION BY
DRAINAGE BASIN¹

<u>Drainage Basin</u>	<u>1970</u>	<u>1990</u>	<u>2020</u>
Pocono Plateau	115,000	336,000	849,000
Flat Brook	45,000	141,000	323,000
Neversink River	89,000	214,000	352,000
Bush Kill	72,000	284,000	795,000
Brodhead Creek	418,000	1,270,000	3,340,000
Cherry Creek	21,000	48,000	128,000
Kittatinny	3,000	11,000	33,000
Paulins Kill	<u>298,000</u>	<u>1,030,000</u>	<u>1,960,000</u>
TOTAL:	1,061,000	3,334,000	7,780,000

¹Exclusive of DWGNRA production. All quantities in pounds per day.

TABLE IV-11
PEAK SEASON AVERAGE DAILY
QUANTITIES OF SOLID WASTE GENERATION
BY COUNTIES¹

<u>County</u>	<u>1970</u>	<u>1990</u>	<u>2020</u>
Pike	321,000	668,000	2,280,000
Monroe	522,000	1,780,000	4,470,000
Orange	139,000	290,000	428,000
Sussex	457,000	1,550,000	2,960,000
Warren	<u>73,000</u>	<u>360,000</u>	<u>690,000</u>
TOTAL:	1,512,000	4,648,000	10,828,000

¹The values in this Table represent solid waste generation for the entire area of each township or borough even though a part of that area (with its associated solid waste generation) may actually lie outside of the TIRES area. DWGNRA generation excluded. All quantities are in pounds per day.

The same flexibility applies to operating a landfill; either a two-shift operation or doubling of manpower and equipment during a single shift would accommodate the peak season requirements.

Unlike water supply and liquid waste disposal, solid waste disposal must be viewed as a cumulative problem. Land for complete disposal by landfill or for disposal of incinerator residue must be set aside for future use. With the average figures from Tables IV-10 and IV-11, an estimate was made for the total land requirements over the 50 year study period. The results of this analysis are presented in Table IV-12 and IV-13. In deriving the estimates, a 15-foot depth of landfill (accomplished in 3- to 5-foot increments) and a compaction factor of 800 pounds per cubic yard were assumed. On this basis, 11 square miles would be needed through 2020 for the study area, and as much as 15 square miles for complete coverage of the five counties involved.

For the DWGNRA, total land requirements for landfill disposal of solid wastes will be approximately 0.7 square miles for the 50-year period. Land for the disposal of non-combustible materials from incinerators would require approximately 20 percent of the values shown in the tables.

TABLE IV-12
ESTIMATED CUMULATIVE QUANTITIES OF SOLID WASTES
AND TOTAL LAND REQUIREMENTS FOR
SANITARY LANDFILL DISPOSAL BY DRAINAGE BASIN^{1,4}

<u>Drainage Basin</u>	<u>Estimated Cumulative Quantities of Solid Waste²</u> (1,000 Cubic Yards)	<u>Estimated Total Land Requirements³</u> (Square Miles)
Pocono Plateau	11,000	1.2
Flat Brook	4,300	0.5
Neversink River	5,000	0.5
Bush Kill	10,000	1.1
Brodhead Creek	42,800	4.6
Cherry Creek	1,800	0.2
Kittatinny	500	0.1
Paulins Kill	<u>25,800</u>	<u>2.8</u>
TOTALS:	101,200	11.0

¹Values based on average solid waste generation rates over the 50-year period.

²Assuming 800 pounds per cubic yard compaction in collection truck.

³Assuming 15-foot depth of landfill, in 3 to 5-foot increments.

⁴DWGNRA production excluded.

TABLE IV-13
ESTIMATED CUMULATIVE QUANTITIES OF SOLID WASTES
AND TOTAL LAND REQUIREMENTS FOR
SANITARY LANDFILL DISPOSAL BY COUNTIES^{1,4}

<u>County</u>	<u>Estimated Cumulative Quantities of Solid Waste²</u> (1,000 Cubic Yards)	<u>Estimated Total Land Requirements³</u> (Square Miles)
Pike	29,500	3.2
Monroe	57,000	6.1
Orange	7,000	0.8
Sussex	38,800	4.2
Warren	<u>8,800</u>	<u>0.9</u>
TOTALS:	141,100	15.2

¹Values based on average solid waste generation rates over the 50-year period.

²Assuming 800 pounds per cubic yards compaction in collection truck.

³Assuming 15 feet depth of landfill, in 3 to 5 foot increments.

⁴The values in this Table represent quantities for the entire area of each County. Even though a part of the area (with its associated quantities) may actually lie outside of the TIRES area. DWGNRA production excluded.

BRIEF DESCRIPTIONS OF ALTERNATIVE PLANS

Water supply.--The existing water supply systems described in Appendix G will be capable of supplying only a small fraction of the future water demands in the TIRES area. The existing 32 public and private water supply systems presently serve a peak summer population of 66,000 with an average daily demand of 8.3 mgd. By 1980, the summer average daily water demand in the study area will exceed 41 mgd, and by the year 2020 almost a million people will require 139 million gallons a day.

This does not mean, however, that all existing facilities are obsolete. On the contrary, the four major systems in the study area (serving Stroudsburg, East Stroudsburg, Newton, and Port Jervis) all provide a high-quality supply at a reasonable cost within their respective service areas. A limited increase in all four of these systems is possible, either by increasing surface-water sources or by supplemental ground-water development.

The growth expected in the study area during the next 50 years necessitates a thorough evaluation of water-supply potential and systems development on a regional scale, rather than consideration of minor modifications to each localized system. Several of the major communities in the TIRES area, faced with increasing water demands, have undertaken studies of their own systems. While the conclusions reached in each of these studies are valid for the respective communities, only rarely do they take into consideration the water demand which will exist beyond the political boundaries of the community sponsoring the study.

As indicated previously, the detailed study of individual water supply systems is beyond the scope of TIRES. Peak water supply requirements have

been presented on both sub-basin and minor civil division bases, but the analysis performed herein places greater emphasis on water demand by watershed.

Ground-water supply. --A review of the general geological information has indicated that the major formations have excellent aquifer capacity. Based on this information, the first objective in the analysis of water supply was maximum utilization of ground-water potential.

After evaluation of the resources, each sub-basin was then studied for future water requirements for both winter and summer usage in the years 1990 and 2020. These requirements were expressed on the basis of mgd per square mile for each sub-basin area and are shown in Table IV-14, which also shows a summary by sub-basin of potential ground-water yields, with the usable yield being compared with the peak summer demand for each sub-basin.

The preliminary comparison of these figures indicated that the future water requirements from all but eight of the sub-basins might be satisfied by utilizing only ground-water sources. In the eight sub-basins where the future demands will not be entirely satisfied by ground water, various alternatives were considered. Special hydrologic conditions in five of the sub-basins indicate the additional quantities of water can be withdrawn from the aquifers without significantly lowering the water table or reducing streamflow.

Each sub-basin was correlated with the geologic information in order to determine which major formations were located within the sub-basin. For each respective formation, the average potential yield of major wells was estimated under the assumption that each of these major wells would be properly located and drilled to optimum depth. These average yield values by information are shown in Table IV-15.

TABLE IV-14
ESTIMATED GROUND-WATER YIELD
VERSUS
FUTURE TOTAL WATER DEMAND
(EXCLUSIVE OF DWGNRA)

Sub-Basin (1)	Area Sq. Miles (2)	Estimated Yield of Existing Large Wells January 1968 ¹		Future Water Demand (MGD)			
		GPM (3)	MGD (4)	1990		2020	
				Winter (5) 50%	Summer (6)	Winter (7) 70%	Summer (8)
PO-1	55.5	1,097	1.58	0.85	1.70	2.73	3.90
PO-2	28.8	365	0.53	0.30	0.60	1.57	2.20
PO-3	25.4	265	0.38	0.45	0.90	1.57	2.20
PO-4	26.9	770	1.11	0.95	1.90	3.50	5.00
PO-5	28.3	105	0.15	0.70	1.40	1.26	1.80
NE-1	62.3	1,123	1.62	1.75	3.50	3.57	5.10
NE-2	11.4	830	1.20	0.30	0.60	0.84	1.20
FL-1	67.6	894	1.29	1.30	2.60	3.92	5.60
FL-2	14.8	287	0.41	0.05	0.10	0.14	0.20
BU-1	98.0	365	0.53	1.85	3.70	6.44	9.20
BU-2	34.0	170	0.24	0.40	0.80	1.54	2.20
BU-3	33.9	45	0.06	0.50	1.00	1.89	2.70
BR-1	65.8	730	1.05	2.15	4.30	6.92	9.90
BR-2	48.8	1,127	1.62	1.44	2.90	4.83	6.90
BR-3	47.9	1,715	2.47	1.72	3.44	6.16	8.79
BR-4	69.2	1,027	1.48	1.21	2.43	5.00	7.16
BR-5	28.9	325	0.47	2.15	4.30	6.70	9.60
BR-6	30.5	450	0.65	2.15	4.40	6.15	8.90
CH-1	26.4	550	0.79	0.50	1.00	1.61	2.30
KI-1	29.4	130	0.19	0.10	0.20	0.42	0.60
PA-1	37.0	125	0.18	1.00	2.00	2.87	4.10
PA-2	37.4	590	0.85	2.10	4.20	5.11	7.30
PA-3	25.8	309	0.44	1.65	3.30	4.27	6.10
PA-4	75.6	7,893	11.37	5.15	10.30	12.25	17.50
TOTAL	1,009.6			30.72	61.57	91.26	130.45

¹Based on relatively short term pumping tests and other yield data for existing wells. Yield estimates probably would be reduced if wells were pump tested continuously for long periods during a prolonged drought.

²Maximum estimate represents ground-water recharge at 0.75 MGD/sq. mi., derived from Parker et al. (1964), multiplied by the area of the sub-basin.

³In the absence of specific sub-basin recharge data, a factor of 20 percent of the generalized basin estimate, 0.75 MGD/sq. mi., is assumed for all sub-basins. This factor appears to be conservative, and need not be refined except for sub-basins for which the calculated ground water yield is marginal or inadequate when compared with demand.

⁴Column 14 minus Column 8, rounded to nearest tenth, except for BU 1, BR-5, BR 6.

⁵Indicated deficit may be reduced or eliminated by refinement of the projected 2020 demand, as shown in Column 8, or by refinement of the estimated design ground-water yield, as shown in Column 14. Any residual deficit possibly can be made up by transfer of ground water from adjoining sub-basins.

⁶Total ground water development is not feasible because of relative locations of demand centers and potential well fields.

⁷These indicated deficits will probably have to be met by surface water supplies; total deficit approximately 15.20 MGD.

Demand per Square Mile MGD/Sq. Mi.				Estimates of Potential Ground-Water Yields, MGD		Ground-Water Surplus (+) or Deficit (-) in 2020 MGD ⁴ (15)
1990		2020		Maximum ² (13)	Design ³ (14)	
Winter (9)	Summer (10)	Winter (11)	Summer (12)			
0.015	0.030	0.049	0.070	41.63	8.33	(+) 4.4
0.010	0.020	0.055	0.078	21.60	4.32	(+) 2.1
0.018	0.035	0.062	0.088	19.05	3.81	(+) 1.6
0.035	0.070	0.130	0.186	20.18	4.03	(-) 1.0 ⁵
0.025	0.050	0.044	0.064	21.23	4.25	(+) 2.4
0.028	0.056	0.057	0.082	46.73	9.35	(+) 4.2
0.026	0.053	0.074	0.105	8.55	1.71	(+) 0.5
0.019	0.039	0.058	0.083	50.70	10.14	(+) 4.5
0.003	0.007	0.010	0.014	11.10	2.22	(+) 2.0
0.019	0.038	0.066	0.094	73.50	14.70 ⁶	(-) 4.6 ⁷
0.012	0.023	0.045	0.065	25.50	5.10	(+) 2.9
0.015	0.030	0.056	0.080	25.43	5.08	(+) 2.4
0.033	0.065	0.105	0.150	49.35	9.87	0.0
0.030	0.059	0.099	0.141	36.60	7.32	(+) 0.4
0.036	0.072	0.130	0.180	35.93	7.19	(+) 1.6 ⁵
0.018	0.035	0.070	0.103	51.90	10.38 ⁶	0.0
0.074	0.149	0.232	0.331	21.68	5.77	(-) 4.0 ⁷
0.070	0.141	0.202	0.288	22.88	4.57 ⁶	(-) 6.6 ⁷
0.019	0.038	0.061	0.087	19.80	3.96	(+) 1.7
0.003	0.007	0.014	0.020	22.05	4.41	(+) 3.8
0.027	0.054	0.078	0.111	27.75	5.54	(+) 1.4
0.056	0.112	0.137	0.195	28.05	5.61	(-) 1.7 ⁵
0.064	0.128	0.165	0.236	19.35	3.87	(-) 2.2
0.068	0.136	0.162	0.231	56.70	11.34	(-) 6.2 ⁵

TABLE IV-15
AVERAGE POTENTIAL WELL YIELDS
OF
GEOLOGIC FORMATIONS
IN THE TOCKS ISLAND REGION

<u>Symbol</u>	<u>Geologic Formation</u>	<u>Potential Yield</u> gpm
Unc	Valley bottom glacial deposits	350+
Dc	Catskill	200
Dp	Portage	100
Dh	Hamilton - Mahantango Only	100
Dsl	Onondaga	150, 75-250
	Esopus	75
	Oriskany	100-250
DS	Helderberg	100
Sb	Bloomsburg	200
Ss	Shawungunk	50
Om	Martinsburg	100
OGc	Carbonates (except Jacksonburg)	300
PG	Gneisses	75

Each sub-basin was then examined in detail, and potential well fields were generally located. The well-field locations were checked against the future land-use pattern, and the estimated supply was matched to future demand by development stage. For water supply planning purposes, Stage 1 is the period from 1970 through 1990, and Stage 2 represents the years 1990 through the end of the study period (2020). Wherever ground water is both adequate and convenient, the future water demand in mgd for each sub-basin is assumed to be met by the required number of wells in each aquifer within the respective sub-basins.

Detailed information on the numbers of wells, recommended development period, and other related data are open-file information. It is recognized that the new wells, required during the first stage (1970 to 1990), will actually be undergoing construction throughout the period and will not be built at any one given time. For this reason, generalized well-field locations are shown in lieu of specific well sites. Any field could readily be relocated, if future land development differs from the anticipated pattern or if it is desirable to provide a more uniform distribution of ground-water withdrawal in the latter period of Stage 1 development. The same pattern would apply to ground-water development in the second stage.

As each sub-basin was analyzed, the estimated usable ground-water potential shown in Table IV-14 was evaluated to determine whether or not it represented the true ground-water potential for the sub-basin. In some cases the potential value was found to be misleading.

In one sub-basin (BR-5), either the transfer of surplus ground water from adjacent basins or surface-water development will be necessary. In two other sub-basins (BU-1 and BR-6), potential well fields are too remote from future population, and additional sources will be required.

Surface-water development.--For those areas where conservative estimates of potential ground-water yields indicated that they will not be adequate for future summer demand, a study of supplemental water supply was made. The amount of the deficit in each sub-basin was estimated (Table IV-14), and the probable locations of major future population concentrations by sub-basin were examined. While the analysis varied with each deficit area, three basic alternatives were derived:

1. The possibility of developing well fields in adjacent sub-drainage basins with a surplus of ground water potential and transmitting it into the deficit basin was considered. The major cost of water supply development would be for transmission between sub-basins rather than for well-field development.
2. Development of surface impoundments within the sub-drainage basin area was considered. Potential sites for dam structures were taken from the North Atlantic Region Watershed Inventory and from watershed work plans developed by the Soil Conservation Service. Many of the potential dam sites considered by the SCS are primarily for the purpose of flood control, and had to be evaluated quantitatively as to their feasibility for water supply impoundments. Because of limited yield, only a very small number of the sites located within the study area were considered for surface-water development, and each of these would require further study before it could be finally selected as a single or multi-purpose reservoir site.

3. A major portion of the storage volume in the Tocks Island Reservoir has been allocated for future water supply. Since many of the major growth areas lie within a few miles of the reservoir, consideration was given to withdrawal, treatment, and transmission of water from the reservoir to the populated areas.

Each sub-basin with a ground-water deficit was analyzed separately; the comparisons between alternatives for each of the sub-basins are described in detail in Appendix H.

The result of the analysis of deficit-ground-water sub-basins BU-1, BR-5, and BR-6 is a surface-water supply system which would utilize storage volume in the Tocks Island Reservoir allocated to water supply, and which would withdraw, treat, and distribute this water in the valley from Bush Kill inlet to East Stroudsburg, serving major growth areas within the three townships and the Borough of East Stroudsburg. The outline of the service area would depend on the extent and location of population growth, and would be contingent on the difficulty of distribution into the various potential service areas.

The following summarizes the ground-water deficits by sub-basin and indicates the location of the population involved:

Sub-Basin	Ground Water Deficit (mgd)	
	By 1990	By 2020
BU 1	1.8	4.6
BR 5	0.0	4.0
BR 6	2.1	6.6
	3.9	15.2
Estimated Service Population ¹	1990	2020
Middle Smithfield Township	16,500	40,700
Smithfield Township	12,300	34,700
Stroud Township	0	5,000
East Stroudsburg Borough	0	21,000
	28,800	101,400

¹Based on withdrawal from Bush Kill Inlet and distribution to Middle Smithfield and Smithfield Townships in Stage 1; extension to East Stroudsburg Borough and Stroud Township in Stage 2.

The development of a surface supply is felt to be essential to meet the future demands within this valley. The withdrawal of approximately four mgd from the reservoir would have virtually no effect on the reservoir itself, since it represents only about 12 acre-feet per day from an impoundment that is expected to have an average summer storage capacity of 500,000 acre-feet.

Liquid waste disposal

Initially, five alternative sewerage plans were devised and studied, ranging in degree of regionalization from a system of 116 local community collection and treatment works to a single network of interceptor sewers connecting all communities of the study area to a major wastewater treatment plant downstream of Tocks Island Dam.

These five alternative wastewater collection and treatment systems are shown in Figures 1 through 5 and may be briefly described as follows:

Multiple Small Systems (Alternative I).-- This plan features 116 relatively small systems, each serving a local population concentration, with wastewater collection and treatment capacity ranging from 0.02 to 5.0 million gallons daily. Alternative I represents the historical approach to sewerage, with minimum regionalization. This plan would serve a sewered peak-season population of approximately 673,600 in the year 2020¹ (Figure 1).

Limited Subregional Systems (Alternative II).-- This plan provides for some regionalization, with consolidation of many of the small systems serving local areas into 52 systems, ranging in capacity from 0.02 to 24.0 mgd. The total 2020 population served by these systems would be approximately 752,000 during peak seasons (Figure 2).¹

¹ In addition to the DWGNRA visitor population (141,500 estimated peak-day load at full development).

Subregional Systems (Alternative III).--This plan provides for considerably more regionalization than Alternative II. It is composed of six separate collection and treatment systems with capacities ranging from 3.6 to 28.0 mgd². These systems would serve an aggregate peak season population of 795,500 in the year 2020¹ (Figure 3).

Regional System from Subregional (Alternative IV).--This plan is initially the same as Alternative III, with six subregional systems being developed through the year 2000. After the year 2000, these subregional systems would be consolidated to form a single collection system that would convey all liquid wastes from sewerred communities throughout the study area to a central treatment facility located downstream of Tocks Island Dam². This plant, with a capacity of 90 mgd, would serve a 2020 peak summer population of 840,500¹ (Figure 4).

Regional System (Alternative V).--This plan would provide at an earlier date the same system called for after 2000 under Alternative IV, with an ultimate capacity of 90 mgd³. This alternative would also serve a 2020 peak season population of 840,500¹ (Figure 5).

For comparative purposes, an Alternative VI was developed as a combination of Alternatives I and III. Alternative I would be used during the first Phase (1970 to 1980) and then abandoned during the second Phase (1980 to 2000). Alternative III would be implemented during the second and third Phases.

¹ In addition to the DWGNRA visitor population (141,500 estimated peak-day load at full development).

² In addition to the six subregional plants or one regional plant, there would be 15 very minor facilities serving isolated areas. These 15 facilities would serve only one percent of the service population, and hence are excluded from this discussion.

³ In addition to the one regional plant, there would be 15 very minor facilities serving isolated areas. These 15 facilities would serve only one percent of the service population and are not elaborated upon.

Detailed descriptions of each of the alternatives are presented in Appendix H.

The development of the systems under each alternative has been staged to correspond with population growth in the study area. None of the alternatives could or should be built at one particular time; each plan should be implemented to meet the demand. Since population growth will not occur at a constant rate over the 50-year study period, three Phases of systems development and construction have been considered as follows:

Phase 1: 1970-1980 (Beginning of major growth period)

Phase 2: 1980-2000 (Period of maximum growth rate)

Phase 3: 2000-2020 (Period of relative increase in permanent residential population)

The recommended staging of each alternative has also been shown on Figures 1 through 5. Table IV-16 summarizes the required major system components for each of the alternatives, when ultimately developed to full capacity in the year 2020.

The particular wastewater problem within the TIRES area, and a most difficult obstacle to overcome, is collection, not treatment. Historically, sewerage systems have been developed following the natural terrain of the proposed service area. The flow of wastewater in the network of collection lines normally is by gravity, and the extent of sewerage systems has been generally limited to natural drainage basins. The prospect of developing a wastewater collection system to service the TIRES areas, encompassing over 1,000 square miles of relatively rugged terrain, is unique among modern collection systems.

Since the problem is so unusual, the various alternatives were developed and evaluated in order to select that alternative or combination of

TABLE IV-16
SUMMARY OF SYSTEM COMPONENTS
ULTIMATE DEVELOPMENT

<u>Alternative</u>	<u>Number of Major Treatment Plants</u>	<u>Miles of Major Interceptor and Trunk Sewers</u>	<u>Number of Major Pumping Stations</u>
I	116	-----	-----
II	52	473	196
III	6	535	261
IV	1	565	275
V	1	565	275

alternatives which would prove economically and technically feasible. While each alternative is intended to stand alone, it is possible that an evolutionary process, such as discussed under Alternatives IV and VI may occur. With time, this would mean an increasing degree of regionalization and greater overall costs resulting from phasing-out of treatment facilities and duplication of collection system components.

Discussion of Alternatives.--Each of the alternatives represents varying degrees of advanced planning and co-operative effort. The establishment of a regional agency to develop the systems and the degree of involvement of various federal and state agencies will materially affect the type of system that evolves. For example, while any of the alternatives could be developed as a Master Plan administered by a regional water pollution control agency, the first alternative is probably closest to what would evolve with little or no overall planning, a minimum of outside assistance, and very little inter-governmental cooperation.

The rationale behind Alternative I is that a wastewater collection and treatment system would be built to serve each individual pocket of development and population growth as the need occurs. The development of such small systems could lag behind the demand created by the population influx. Where a regionalized system may anticipate a need prior to actual demands, the conventional approach covering the same area would probably follow demand rather than anticipate it. While there is some validity to the argument that a multiplicity of plants would minimize the effect of effluent discharge, the cumulative effect of 116 individual treatment facilities throughout the study area would present a much greater pollutional threat. While many of these facilities would be of substantial capacity, there is an inherent danger of poor operation with the smaller treatment facilities. It is

an established fact that with larger plants greater control can be exerted and a higher quality of effluent produced. The demand fluctuations and the shock loadings that occur with any plant can be better handled by a large facility. The reliability of treatment plants of different sizes is discussed in Section V.

The detailed description of Alternative I presented in Appendix H outlines the evolution of wastewater collection and treatment systems that can and will develop if each individual community and political sub-division attempts to solve its own problem.

While the percentage of the population ultimately served by Alternative I is substantial, it must be recognized that the 26 percent of the population not served in the year 2020 represents more than 250,000 people utilizing on-site disposal systems (exclusive of DWGNRA). This means a large number of septic tanks and drainage fields, many located in poor soil and probably contaminating the land and water. The pollutional effects on the ground water resulting from Alternative I cannot be overlooked or minimized.

The cost summary for Alternative I shown in Appendix I reflects several interesting facts. The ratio of treatment costs to collection costs is about 3 to 1. Under all other Alternatives to be discussed, the cost of treatment will be less than the cost of collection. For the majority of the small treatment plants proposed, the demand that would exist at the time of plant construction would be less than one-half of the ultimate design capacity. This inefficiency in plant utilization is conspicuous with such a system of multiple small plants.

In addition, such a system is not easily adapted to the development required as growth occurs; a larger, central treatment plant can be built in stages more readily than can a combination of small plants. The collection system for small treatment plants, however, will be much more efficient.

With relatively little pumping necessary, only small lengths of trunk sewers will be required, and there will be relatively little oversizing of lines. By contrast, the collection system for more regionalized plants would have many components with substantial excess capacity initially.

The second Alternative is presented as an intermediate step between Alternatives I and III. It utilizes the subregional concept in part, and provides for expansion of the subregional systems as the need occurs. In addition, those areas where interconnection of collection system components is relatively costly, will still be served by small individual treatment facilities. In other words, Alternative II attempts to compromise to obtain the most desirable features of both individual and subregional systems. While all Alternatives are developed in increments, the staging of collection system components is most efficient under Alternatives I and II. This is particularly true in Alternative I because the first development stage has been limited to those areas where future growth is most obvious. Because most of the needs for service in the TIRES area are anticipated and do not exist now, the development of systems to serve the future population becomes much more complex as the analysis attempts to extend collection systems and centralize treatment processes.

Under Alternative III, the sub-regional concept, the number of major treatment facilities is reduced to six to decrease the construction, operation, and maintenance costs of treatment and to exercise a greater degree of control over effluent quality and protection of the environment. Four of the sub-regional plants in Alternative III are expanded versions of the limited subregional plants discussed in Appendix H under Alternative II, while the remaining two sub-regional plants are combinations of the limited facilities in Alternative II. Each collection system still attempts to follow the natural drainage patterns wherever possible.

As under Alternative II, the six plants in Alternative III have been located as close as possible to the regions which they will serve. Each sub-regional treatment plant would eventually be served by an extensive collection system, portions of which could be developed in stages.

A major shortcoming with such a regionalized system is that development does not necessarily occur at a uniform rate throughout the proposed service areas. There are some remote communities (i.e. not close to a treatment plant) where an immediate need exists for wastewater collection and treatment. Many of these areas cannot await further development of adjacent regions. Therefore, implementation of Alternative III could be more difficult than I or II because immediate development would necessitate pre-release of funds. Thus, responsibility for development of such a system must be assumed by a central agency with large federal and state subsidies to pay that portion of the initial development which could not otherwise be met by the local residents and the local economy.

Alternatives IV and V are based on the premise that discharge of even the most highly treated wastewater to the reservoir or its tributary streams within the TIRES area is unacceptable. To comply with this premise, all liquid wastes must be transported from the upper study area and treated below the Tocks Island Dam. The development of such a collection system in stages would be extremely difficult. The major wastewater flows will occur at various points at different times. Some of the longest and most expensive components of the collection system would have to be built to interconnect immediate demand areas. The anticipated population growth along the length of major interceptors, (which normally would be needed to justify their construction) will probably not occur for many years. Furthermore, the technical complications of such a collection system would include large-scale pumping facilities and many other additional features, such as aeration of the raw wastewaters at the major pumping stations.

Solid waste disposal

As indicated previously in this report, solid waste disposal planning concentrated on the use of sanitary landfills. The plan, as developed and as explained in detail in Appendix H, delineates service areas and indicates suitable generalized locations for landfill operations within each service area. Although specific disposal sites were not selected, generalized areas for **the disposal sites were considered.**

The selection of service areas has been affected by the highway network and by the general topography of the area. Some of the controlling topographical features are the Delaware River crossings, mountains, and stream gorges. Four major bridges will provide cross-river access after the completion of the reservoir project: Portland-Columbia Bridge, Delaware Water Gap Bridge, Milford-Montague Bridge, and the twin bridges between Port Jervis and Matamoras. There will be no bridge between the Water Gap and Milford, a distance of about 35 miles.

Transportation routes and available landfill sites were considered stronger determinants than State boundaries, existing political divisions, and other factors which tend to result in a higher total cost of disposal. Integrated service areas, based upon optimum collection and disposal plans, can probably minimize solid waste disposal costs and thereby present a strong case for solid waste management.

There are ten service areas that can reasonably dispose of all solid wastes within their respective areas over the study period. The boundaries of the service areas are not intended to be precise, and transportation of solid waste may require hauls of greater than ten miles. The boundary lines attempt to conform generally with the boundaries of minor political divisions within the TIRES area.

The service areas are described as follows:

1. Northern Warren: Hardwick Blaiirstown, and Knowlton Townships and the greater Portland Borough area in Pennsylvania, also the Water Gap and Kittatinny sections of the DWGNRA.
2. East-Central Sussex: Aparta, Andover, Lafayette Townships and the Town of Newton.
3. West-Central Sussex: Stillwater, Fredon, Hampton, and Frankford Townships and Branchville Borough.
4. North-Western Sussex: Sandyston and Montague Townships, also the Milford (in part) and the Minisink Section of the DWGNRA, and part of the solid waste from High Point State Park.
5. West Orange: The Towns of Port Jervis and Deerpark.
6. North-Eastern Pike: Westfall and Milford Townships and the Boroughs of Matamoras and Milford. There may not be an acceptable site in this service area; therefore, this area could be combined with the West Orange Service Area.
7. East-Central Pike: Delaware and Dingman Townships and parts of Porter, Blooming Grove, and Shohola Townships; and the Dingmans Creek section of the DWGNRA.
8. Pike and Monroe: Lehman, Middle Smithfield, and (partially) Porter Townships; and the Bush Kill Creek section of the DWGNRA.
9. Northern Monroe: Barrett, Price, and Paradise Townships and Mount Pocono Borough.
10. Southern Monroe: Stroudsburg, East Stroudsburg, and Delaware Water Gap Boroughs; Smithfield, Stroud, Hamilton, Jackson, and Pocono Townships.

V. SELECTION OF MASTER PLANS

In this section, the advantages and disadvantages of the various alternative plans are discussed, and reasons are presented for selection of those plans recommended for implementation.

It is re-emphasized here that this study is not intended to serve as a basis for immediate construction of facilities. Rather, the goal of this study is to reveal those broad approaches to problem solutions that merit further detailed studies. (For proper evaluation of the alternatives the reader must be cognizant of this fact.) Only after such detailed studies can the construction phase of plan implementation begin. The discussions and recommendations presented herein have been developed within this context.

LAND USE

Before the various alternative plans for water supply and waste disposal are compared, land-use alternatives should be discussed. The TIRES area might develop in an infinite variety of ways. Wide variations in land-development policies have been enunciated by the local governments in planning for their jurisdictions, and substantial differences exist in the requirements for land subdivision in the various townships and counties comprising the TIRES area. Land-development pressures cannot be accurately defined at this time because the effects of the reservoir and National Recreation Area are just beginning to be felt. Some of the factors that will create a demand for land development are improved access highways, increased free time, and the growing trend of second-home ownership. None of these factors is subject to accurate prediction. Therefore, it would not be realistic to isolate a specific regional land-use pattern for application to this study.

It must be emphasized that this study is not designed to develop or to recommend a specific master plan for future land use. The data on natural resources in the region, and on past and current trends in use and development of these resources--including land--accumulated during this study, will be important information for community and regional planners. However, it should be recognized that much additional information and study will be required to support a valid master plan for future land use in the entire area covered by this study.

It must be recognized also that legal and institutional constraints will have to be overcome before any regional land-use plan, once adopted, can be implemented. This in itself would take years--during which local land-development activity for the most part will continue without reference to a regional comprehensive plan.

As indicated earlier, the Sketch Plan was used as a basis to identify service areas for developing water supply and liquid waste disposal alternatives. While the Sketch Plan is described as a single "plan", it is in reality a concept of how the area might or should develop to exploit the region's recreation and environmental potential without despoiling these characteristics. TIRES has taken another step, with refined existing land-use information from more recent study, supplemented by new population estimates on which to base the overall feasibility of water supply and waste disposal plans.

The Sketch Plan does not formally represent State, county, or local policy. Therefore, there is a further chance for variation from the Plan relative to land-use patterns. Historically, local zoning has not been completely effective in the control of land uses, and if this situation prevails in the TIRES area, the basic assumptions of the Sketch Plan could be easily invalidated, especially with respect to open space.

For these reasons, it appears necessary and wise to plan water supply and waste disposal facilities on the basis of projected, rather than planned, land use. This is not to condone unwise land-use decisions--It is merely a recognition that the goal of optimum planning and control of land use in the Tocks Island Region has not yet been reached, and that protection of public health and water quality requires consideration of the probable land use, which may be vastly different from the optimum concept.

This approach is not as pessimistic as it may appear at first glance. Decisions that will result from this study are dependent only to a limited degree on the types of land uses that are eventually developed. Many decisions regarding water supply and waste disposal necessarily must await more detailed engineering and planning studies. In such subsequent studies the

latest trends in land use planning, control, and development can be taken into consideration. Hopefully, by the time detailed pre-construction studies are completed, the development of land-use plans and institutional arrangements for their effective implementation will have progressed substantially and uniformly throughout the Tocks Island Region.

There are now in existence some controls or constraints on land use. Some local governments have adopted zoning ordinances and land subdivision regulations as means for direct control. Indirect controls also exist, in the form of laws or regulations designed to protect water quality. The pollution control agencies of New Jersey, New York, and Pennsylvania, as well as the Delaware River Basin Commission, all have active programs to promote the preservation and enhancement of water quality in the Tocks Island Region. Water quality standards have been adopted by all of these jurisdictions, and the standards are being enforced. Meeting these high standards may make it prohibitively expensive for some land uses that, although undesirable, would probably otherwise be developed in the region.

There have been expressions of concern that adoption of a generalized sewerage plan for the region will promote development of land not in accordance with optimum land use. Such concern is based on an assumption that sewerage systems will be constructed in undeveloped areas, without regard for a sound land-use plan. This is not generally the case--ordinarily, sewerage systems cannot be financed until there is a firm commitment of land uses requiring sewerage. Thus, land development commitment usually precedes sewerage, and when sewerage systems are installed, the question of land use generally has already been decided.

There may be exceptions to this generality. For example, a sewer that crosses undeveloped land to a remote treatment plant may tend to promote development all along the sewer line. Such a sewer with excess capacity may

be used to encourage sound land development. Special sewerage financing* would be required to make such a plan successful. However, even with special financing of excess sewer capacity, the existence of the excess capacity would tend to promote development only if connection and service charges were less expensive than those of the alternatives available to would-be developers, such as on site disposal systems or local community sewerage systems. In a case where it is considered to be in the public best interest to deter connections to a cross-country sewer, it would probably be no more difficult to deter connections than to deter alternative disposal methods such as on-site disposal.

In summary, land use in the Tocks Island Region may be beneficially controlled, in part, by well-planned sewerage systems. It is more likely that existing land use or land-use commitments will guide the development of sewerage systems. Actual design and construction of these systems must await land-use commitments unless special financing is available. To the extent that the adopted generalized sewerage plan does not conform to land-use commitments, the plan must be modified for special financing before construction of the wastewater disposal facilities.

*Special financing is defined as financing by a special agency to make up the difference between actual annual costs and the costs borne by users paying normal use rates.

WATER SUPPLY

Surface and ground-water resources are more than adequate to meet the projected demands for the region during the next fifty years. These resources are generally well distributed throughout the region, and supplies can be developed without the necessity of long-distance transmission facilities. In some cases, however, economics or local preference may dictate pipelines to a source other than the nearest, even though the latter may be adequate in quantity and with proper treatment in quality.

Because of the relative abundance of water in the Tocks Island Region, the selection of the best plan or plans to meet the projected demands within the region does not appear to be as urgent or as difficult as the other problems considered in this study. Development of the available resources will be needed, but the resources themselves will not be a factor limiting the economic development of the region as projected through the year 2020, provided that the quality of the surface and ground waters of the region can be protected from contamination.

Surface water

Further development of surface-water supplies will likely be the favored approach for those larger population centers in the region now served by surface-water supplies. These centers include Port Jervis, N. Y., East Stroudsburg and Stroudsburg, Pa., and Newton, N. J., which already have considerable investments in surface-water systems. They also have a population base adequate to support the costs of the collection and treatment necessary to convert surface waters into potable supplies. Such costs are substantially higher than those for ground water. Moreover, the future populations of these principal centers may be greater than could be supplied entirely from nearby ground-water sources. Ground-water sources may, nevertheless, be used to supplement surface sources in some of these areas.

Port Jervis.--The City of Port Jervis, situated at the confluence of the Delaware and Neversink Rivers, is in a most favorable position with respect to surface-water resources. Should this city's growth and increased demand for water exceed the limits of its present surface supply, nearby ground-water sources can be developed to augment the existing supply, or the Neversink River or the Delaware River can be developed as a further surface source. Port Jervis now has an emergency intake on the Neversink River, but the use of either river as a regular source would necessitate the construction of a water-filtration plant, a step likely to be more expensive than developing ground-water sources.

East Stroudsburg.--The Borough of East Stroudsburg is conveniently located near several streams that could be developed to meet at least part of its long-range future water demand. These streams include Brodhead Creek and two of its tributaries, Michael Creek and Marshall Creek. East Stroudsburg, could also go to the Delaware River for additional water, either directly from Tocks Island Reservoir or from the regulated river below Tocks Island Dam. However, a water-filtration plant would be required if any of these surface-water sources were to be used. Some fringe areas, not convenient to distribution mains of the surface-water system, could probably be served by local well fields.

Stroudsburg.--The Borough of Stroudsburg is located near sizable streams that could be developed to provide the additional water supplies to meet its projected long-range needs. Brodhead Creek forms part of the eastern boundary of the Borough, and McMichael Creek traverses the Borough. The drainage area above Stroudsburg of about 325 square miles would furnish the potential for development of a relatively large supply. As with East Stroudsburg, the Borough of Stroudsburg is near the Delaware River and not far from the site of Tocks Island Reservoir, either of which

can be tapped in the long-range future. Again, utilization of surface-water sources would require a water-filtration facility. As an alternative measure, ground water in the area could be developed to serve some of the environs of Stroudsburg, at least until such time as the Borough's distribution system is extended to these areas.

Newton.--The Town of Newton, New Jersey, imports water from Lake Morris, a reservoir in eastern Sussex County on a tributary of the Walkill River in the Hudson River Basin. The pipeline from the reservoir to the town runs about eight miles. This surface supply has been in use since about 1896. During recent severe droughts, it was augmented from emergency sources.

The Newton surface water system can be expanded either by increasing the diversion from Lake Morris, or by use of water from Paulins Kill. A Paulins Kill supply system would require a filtration plant. However, prior to the development of either additional surface water source, ground-water sources should be thoroughly investigated because of the potential for significant cost savings.

Other areas.--Areas other than those discussed above have been studied in this project with respect to surface-water supplies. Most of the surface sources near these areas are limited in yield, but with the addition of surface storage reservoirs, they could serve many of the sub-areas of the region well into the future, either as alternatives or supplements to ground-water supplies.

The Soil Conservation Service inventory of potential reservoir sites in the region provides a starting point for further study of surface storage sites.

Ground water

The study has indicated that sizable well-yields can be developed in most parts of the Tocks Island Region, provided that the wells are located and constructed in accordance with modern principles of ground-water hydrology. Ground water, where adequate, has certain inherent advantages over surface water. One is that wells can often be located very near the point of water use, thus obviating the need for long transmission lines. Another advantage is that ground water usually does not have to be treated as extensively as surface water to make it potable or otherwise suitable for use. A third is that a smaller area is needed to develop a well system than to construct a reservoir. A fourth advantage is the relative ease of protecting wells from contamination, as opposed to protecting surface waters. In addition, ground-water quality does not vary with seasons as much as does surface-water quality. All of these factors tend to make ground water significantly less expensive to develop than surface water. In the TIRES area, approximate costs of \$0.10 and \$0.45 per thousand gallons can be expected for development of ground- and surface-water resources, respectively. Clearly, significant savings can be realized by the development of ground-water sources where possible.

The historical tendency in community water supply development has been to develop ground water first. If and when demand for water increases to the point that it no longer can be met by the yield of available aquifers, the change is made to surface-water sources. This approach has the advantage of lower cost per unit of water use during the period of relatively small systems that cannot take advantage of economies-of-scale. Later, after community growth, these economies-of-scale tend to offset the higher cost of surface-water collection and treatment.

Available information on potential ground-water yields indicates that the water demands projected for most areas of the region through 2020 can be met by development of ground water resources. This finding, together with the low unit cost of ground water, favors ground-water development wherever possible for communities in the study area.

As mentioned earlier, the Borough of Delaware Water Gap was studied in some detail as a separate part of this investigation. A new surface-water system with a reservoir, a filtration plant, and other necessary ancillary facilities was estimated to cost about \$500,000 in 1967. By comparison, the existing ground-water system could be improved and expanded at a 1967 cost of only \$85,000. (Both costs include the present--1967--worth of annual operating costs.) These estimates and other details of the Delaware Water Gap water supply investigation are presented in separate reports (ROY F. WESTON, 1967). The results of this investigation are a good example of the economy of ground-water development.

Unfortunately, the scope of this study did not permit investigation of the ground-water potential in all sub-areas in the detail carried out for the Borough of Delaware Water Gap. For the region as a whole and for most sub-areas within the region, ground-water yields were estimated to average approximately 150,000 gpd per square mile. While it should not be inferred that any specific locality can depend on such yields, the probability remains high that most communities in the region could develop adequate ground-water supplies at a cost less than that of an equivalent surface supply.

Before any new surface supply or any expansion of an existing surface supply is undertaken, the sponsor should carry out a program of detailed investigation of ground-water availability in and near the area of demand. Only where ground water is shown to be unavailable in adequate quantities should a community undertake the more costly surface-water development. (See Tables IV-14 and IV-15).

LIQUID WASTE DISPOSAL

Cost concept

The costs analyses of each of the six alternative plans for liquid waste disposal have been computed as part of this investigation. In the present worth analysis (described later in this section), an attempt has been made to depart from the conventional practice, in sewerage studies, of considering only the costs of interception and treatment. All costs of liquid waste disposal, direct and indirect, that could be identified and quantified have been estimated for each of the alternatives. These estimates are presented in Appendix I, in terms of capital costs as well as operation and maintenance costs. All capital costs have been converted to annual costs for an amortization period of 40 years and an interest rate of seven percent. The annual costs resulting from these basic assumptions were subjected to sensitivity tests using different amortization periods and interest rates. These sensitivity tests also are described later in this section and in Appendix I.

Summary of capital and annual costs

The capital and annual costs presented in Tables I-1 through I-10 in Appendix I are summarized in Tables V-1 through V-4. These costs cover only interceptor and trunk lines, major pumping stations, and treatment plants, and do not include intra-community collection costs. The cost figures in Table V-3, which are estimates of average annual costs for the TIRES area, were divided by the estimated number of people that would be served by each of the Alternatives in each construction period, to obtain per capita cost estimates. These per capita figures are presented in Table V-4. Details of the cost analyses are presented in Appendix I.

Tables V-1 and V-2 indicate that Alternative I has the lowest capital cost requirement. Alternatives II and III have the same approximate

TABLE V-1

SUMMARY OF ESTIMATED CONSTRUCTION COSTS
OF LIQUID WASTE DISPOSAL SYSTEMS
BY CONSTRUCTION PERIOD

	Costs, millions of dollars			Total
	1970-1980	1980-2000	2000-2020	
Alternative I	58.9	44.6	8.1	111.6
Alternative II	66.7	63.1	16.4	146.2
Alternative III	77.5	51.9	27.1	156.5
Alternative IV	77.5	51.9	80.0	209.4
Alternative V	112.7	49.5	27.9	190.1
Alternative VI	58.9	78.2	78.1	215.2

TABLE V-2

SUMMARY OF ESTIMATED TOTAL PROJECT COSTS
OF LIQUID WASTE DISPOSAL SYSTEMS
BY CONSTRUCTION PERIOD

	Costs, millions of dollars			Total
	1970-1980	1980-2000	2000-2020	
Alternative I	70.6	53.5	9.7	133.8
Alternative II	80.1	75.7	19.7	175.5
Alternative III	93.0	62.3	32.5	187.8
Alternative IV	93.0	62.3	96.0	251.3
Alternative V	135.2	59.4	33.5	228.1
Alternative VI	70.6	93.9	93.9	258.4

TABLE V-3
SUMMARY OF ESTIMATED AVERAGE ANNUAL COSTS FOR
LIQUID WASTE INTERCEPTION AND TREATMENT
(For various assumed construction
grants, by construction periods)

System	Costs, millions of dollars								
	1970-1980			1981-2000			2001-2020		
	(0%)	(30%)	(60%)	(0%)	(30%)	(60%)	(0%)	(30%)	(60%)
Alternative I	4.4	3.8	3.2	10.1	9.2	7.3	14.6	12.0	9.3
Alternative II	4.0	3.3	2.6	12.3	10.1	7.9	18.1	14.4	11.1
Alternative III	4.9	4.1	3.3	12.5	10.2	7.8	18.4	15.0	11.6
Alternative IV	4.9	4.1	3.3	12.5	10.2	7.8	21.2	17.1	13.0
Alternative V	6.7	5.5	4.4	15.8	12.7	9.6	21.2	17.0	12.9

TABLE V-4
SUMMARY OF ESTIMATED ANNUAL COSTS PER CAPITA
LIQUID WASTE DISPOSAL SYSTEMS
(Based on average number of persons served by
the systems, assuming a 30% construction grant)

System	Cost per Capita per Construction Period, dollars		
	1970-1980	1981-2000	2001-2020
Alternative I	58	34	23
Alternative II	50	35	24
Alternative III	46	28	22
Alternative IV	46	28	25
Alternative V	59	36	25

requirement, while IV and V are significantly more costly to build. Alternative VI has the highest overall cost because the facilities built in the first construction period would be abandoned in the second and third periods, and new facilities would be required for replacement.

The absolute dollar differences among the Alternatives in annual costs (as presented in Table V-3) are not as great as the construction cost differences, but the same general ranking prevails. This is because treatment costs are relatively high for Alternatives I and II, as can be seen from Appendix I data. The annual costs of Alternative VI are not shown in the table because the annual costs of Alternative VI are obviously higher than those of the other Alternatives, primarily as a result of the amortization costs related to the required replacements in the second and third periods.

Table V-4 shows a substantial cost advantage for Alternative III. Substantially more persons would be served by Alternative III than by Alternative I, reducing per capita annual costs. The values in this table should be given most weight in comparing costs of Alternatives since the basis of comparison, i.e., cost per person served, is common to all Alternatives.

Present worth sensitivity analyses

Because the annual costs of the various alternatives do not take into account the time value of money, they are difficult to compare with respect to cost effectiveness. In order to provide easy and direct comparison of two or more cost series having different outlay patterns over time, it is necessary to reduce each series to a single value at a given time. For realistic financial comparison, the appropriate method of reduction is to discount all costs for a given alternative over the period in question to a specific time and then to add them. The resulting sum is the specific-time value of the costs that are actually to be spread over a significantly long period. If discounted to the present, the specific-time value is usually referred to as the "present worth"

of the future costs. In simple terms, the present worth of future costs can be interpreted as the money that must be invested now at compound interest to provide the money needed to pay the future costs as they come due. In this study, all cost series have been converted to present worth (as of 1970) for comparison.

As mentioned earlier in this section, the present worth sensitivity studies attempt to include all identifiable water quality management costs. Besides the normally included costs of interception and treatment, the study also includes the costs of: 1) on-site disposal for residents not served by sewerage systems; 2) dilution water for low-flow augmentation, and 3) stream quality surveillance and treatment plant monitoring.

Because the interest rate used in discounting affects present worth, future costs have been discounted at three different interest rates, four, five, and seven percent. The use of different interest rates provides a test of the sensitivity of the resulting cost comparisons to changes in the interest rate.

In addition to varying the discount interest rate, a number of other parameters were varied to ascertain what effect, if any, they had on the ranking of alternatives. The following listing indicates those parameters and their respective values which were analyzed:

1. Population projections: three values were assumed--low, medium, and high. The medium values are the projections presented in Section IV of this report, the low and high values were taken as present population plus 75 percent and 125 percent, respectively, of the projected increase.
2. Cost of on-site disposal: again three values were analyzed--low, medium, and high (75 percent, 100 percent, and 125 percent of medium values).

3. Replacement interval of sewers: 40 years and 100 years.
4. Replacement interval of pumping stations and treatment works: 40 years.
5. Replacement interval of dilution-water reservoirs: 100 years.
6. Period over which the annual costs were considered and discounted to 1970: 1970 to 2020 and 1970 to infinity.
7. Interest rate: 4, 5, and 7 percent.

A total of ten combinations of the various ranges of the parameters were investigated. The initial test used basic assumptions and costs as follows: medium population projections, medium level of on-site disposal costs, 40-year replacement interval for sewers, pumping stations and treatment works, 100-year replacement interval for dilution water reservoirs, 1970-2020 as the period for which annual costs were considered and discounted to 1970, and an interest rate of 5 percent. Table V-5 presents the results of the analysis using these basic assumptions and costs.

The other nine tests were compared with this base case. In seven of the nine, Alternative III had the lowest present worth; in the two tests where it did not, Alternative I was the lowest. The determining reason in one case was that low values of on-site disposal costs were assumed; since Alternative I serves the least number of people by public sewerage systems the assumed low value of on-site disposal costs was a particularly strong influence. The other case where Alternative I showed up as least cost involved the basic assumptions but with a 7 percent present worth discount rate. However, a subsequent sensitivity check with 7 percent discount rate and assumed high values for on-site disposal costs indicated Alternative III as the least-cost choice. As a practical matter, on-site disposal costs are likely to be higher than the medium values used in the base case, because of indicated unsuitable soil conditions in many areas and because of increasingly stringent legislation and enforcement by health authorities.

TABLE V-5
PRESENT WORTH (1970) OF TOTAL WATER-QUALITY
MANAGEMENT COSTS USING
BASIC ASSUMPTIONS AND COSTS

<u>Alternative</u>	<u>Present Worth</u> millions of dollars
I	\$332
II	337
III	328
IV	332
V	362
VI	364

While it cannot, of course, be assumed that the ten cases studied cover all ranges of possibilities, the results of the cost analyses favor the selection of Alternative III. Most important, the studies demonstrate that fairly large changes in assumptions concerning population projections, replacement intervals, interest rates, etc., do not significantly affect the present-worth rankings of the Alternatives. Within a relatively wide range of assumptions, Alternative III remains the most desirable for implementation from a cost standpoint.

Water quality consideration

The major consideration in the choice of a liquid waste disposal plan must be protection of the water quality in Tocks Island Reservoir and of the natural environment of the Tocks Island Region.

Studies have been made of water-quality conditions in the reservoir and how they would be affected by waste discharges. An analysis to ascertain if a significant increase in the eutrophication rate of Tocks Island Reservoir would be caused by waste discharges from the TIRES area was made. The study considered:

1. The physical characteristics of the reservoir and its drainage area,
2. Present nutrient concentrations in the river above the reservoir site,
3. Estimates of total nutrient production, present and future, in the study area and in the upstream drainage area,
4. The operation and hydromechanics of the reservoir, and
5. Reservoir nutrient levels that would result in nuisance algal blooms.

The analysis could not be definitive, because of lack of basic data and information concerning the nutrient cycle in the reservoir. However, enough information was obtained to conclude that liquid waste from the TIRES area should be given advanced treatment to remove approximately 95 percent of

the soluble phosphorus. In addition, nutrient concentrations from the upstream drainage area must be reduced to assure protection of the Reservoir.

Alternatives III, IV, and V are clearly superior to Alternatives I and II in protecting the reservoir and the natural environment. The smaller number of plants and the larger size of the regional plants increases the reliability of the overall system. Greater emphasis can be placed on proper engineering design, construction, and operation. Fully-qualified operators could be obtained more readily, to run the limited number of larger plants, thus promoting more reliable operation. Because regional plants tend to be better built and operated, their reliability of performance will be good. The amount of time they operate below design standards will be minimal as compared to the off-standard time of a large number of small plant operations. This factor is discussed more completely in the systematic analysis of factors other than costs in a later section of this report.

Alternatives III, IV, and V are more consistent with the principle of regionalization which is now supported by State pollution control agencies and the Delaware River Basin Commission. Regionalization provides increased ability to solve water quality problems. It is far easier to monitor and control the operation of a limited number of major regional plants than of a large number of small, scattered treatment facilities.

Waste-loading allocations have not been established for the TIRES area, but water quality standards are in effect. Extensive stream assimilation studies were not conducted, but treatment plants have been located and cost estimates prepared based upon the general requirements of the standards. The DRBC standards state in part:

"Water uses shall be paramount in determining stream quality objectives which, in turn, shall be the basis for determining effluent quality requirements."

To comply with this statement and to recognize that high-quality recreation waters will be required within the TIRES area, advanced treatment in the form of 95 percent BOD and soluble phosphorus removal has been assumed as the required degree of treatment for all waste discharges.

It appears virtually impossible to meet adequately the stream requirements and protect the reservoir and environment with either Alternative I or II, for the reasons cited above. Alternative V offers maximum protection, but it is doubtful that it could be implemented soon enough. Alternatives III and IV have sufficient regionalization to provide adequate protection.

In summary, protection of the reservoir, of stream water quality, and of the environment would be greatest with Alternative V. Protection would be somewhat less with Alternatives III and IV, and would be at a minimum with Alternatives I and II. It is doubtful that Alternatives I or II can provide adequate protection.

Implementation

The alternative master sewerage plans are developed by construction periods on the assumption that sewerage facilities will be provided in time to avoid water quality problems. Historically, the converse has been true, i.e. sewerage systems have been provided after a water quality problem has become a reality.

Because of this problem-avoidance approach, implementation during the first construction period, 1970 to 1980, could require major outlays in advance of growth; therefore, per capita costs are high. The per capita costs in Table V-4 cover only interception and treatment an approximate value of \$15 per capita must be added for collection.

Pre-spending will be required for each Alternative in the period 1970 to 1980. By the second and third construction periods, 1980 to 2000 and 2000

to 2020, the systems become self-sustaining because of the increased population served.

Alternatives I and II have the advantage of relative ease of implementation. However, this is not to imply that Alternatives III, IV, and V could not be implemented. Implementation of Alternatives III, IV, or V would be contingent upon a central agency constructing and operating the interceptors and major trunk lines and treatment plants. Local communities would provide intra-community collection and would contract with the central agency for interception and treatment. It is highly unlikely that local interests could join together successfully to construct the major facilities called for under Alternatives III, IV, or V.

Systematic analysis of factors other than cost

In the comparison of alternative solutions for the purpose of arriving at a decision, cost alone frequently is an inadequate basis. Other factors which may be either tangible or intangible, must also be considered. The DARE (Decision Alternative Ratio Evaluation) technique provides a rational approach to comparison and evaluation of pertinent tangible and intangible factors. Obviously, no technique of itself can substitute for judgment. What DARE does accomplish, however, is to present a listing of all factors which have been considered, judgments of the relative importance of each factor, and estimates of the relative ability of each alternative to meet the criteria reflected by the factors. Where the analyst is not a party to the final decision (as in the case of a consultant preparing facts and recommendations for the client's decision), such a presentation is helpful to the client in determining his agreement or disagreement with the proposed solution.

In the present case, five factors were considered sufficiently important for a comprehensive, balanced evaluation and sufficiently discrete to avoid significant overlapping or interaction. The five factors are:

1. Implementation
2. Adaptability
3. Reliability
4. Costs
5. Social Benefits

Each of the five Alternatives can be implemented, but some will be easier and/or quicker than others. Considerations affecting the relative ease of implementation are:

- a. Public attitudes and reaction.
- b. Cooperation of local governments.
- c. Institutional and political implications and restraints.
- d. Staging of construction.
- e. Financial schedules and monetary assistance programs.
- f. Cost-sharing among political bodies.

Each of the Alternatives has been designed to meet the presently applicable and anticipated stream water quality criteria of the Delaware River Basin. However, it is not unlikely that at some future time the water quality requirements will become more stringent. Consequently, an adequate comparison of the Alternatives should contain an evaluation of the adaptability of each Alternative to respond to the establishment of stricter water quality requirements. Some of the more critical elements involved in evaluating such adaptability are:

- a. Cost of required modifications.
- b. Time required to complete the modifications.
- c. Institutional considerations.

Although the facilities involved in each Alternative have been designed to meet the applicable objectives, each system will probably fail to meet these objectives from time to time because of unaccounted-for variability in raw wastewater characteristics or receiving stream water quality, or because of

unexpected variation in treatment plant efficiency. This latter variation could result from equipment failures, inadequate design, degree of automation, and/or deficiencies in training or performance of operating personnel.

One significant measure of reliability is the relationship between treatment plant size and the percentage of time the quality of the treated effluent will be poorer than the design value. The following equation has been found to be effective in predicting off-specification time:

$$T = 22.5 \times Q^{-0.24}$$

where,

T is percent of time the plant fails to meet design standards, and

Q is treatment plant capacity in million gallons per day.

The relative reliability of each wastewater treatment alternative was determined in the following manner: Random number techniques were used in conjunction with the above equation to determine whether a given plant was performing according to design. This was done for each treatment plant in each alternative, and the fraction of the total wastewater flow missing design efficiency was calculated for that alternative. The procedure was repeated 100 times, and the results provided a probability distribution for each alternative. Application to the five Alternatives is summarized in the following tabulation.

<u>Alternative</u>	<u>Percentage of Time 5 Percent or More of Total Wastewater Flow will be Off-Specification</u>
I	99.8
II	70
III	45
IV	45
V	45

It should be pointed out that the percentage values in this tabulation have significance only for comparison of the Alternatives, i.e. they are relative rather than absolute indicators of performance reliability.

The discussion of Water Quality earlier in this section also presents information relevant to definition of reliability and to its importance as a basis for selection of the most favorable Alternative.

The costs of each Alternative have been extensively discussed and compared in this report, and their importance in decision-making has been clearly established. Construction costs, per capita annual costs, and present net worth values all warrant consideration.

Each of the Alternatives will provide certain benefits of a social nature, such as preservation of aesthetic quality of the Tocks Island Reservoir and of the general area, contribution to the recreation potential of the region, etc. These are intangibles and are difficult to measure, yet the extent to which each Alternative provides such benefits has a bearing on selection of the approach to be adopted.

The relative importance of each of these five factors was determined by an 18-man panel composed of members of the staff of ROY F. WESTON. It was originally developed for a regional wastewater treatment investigation covering an area comparable to the Tocks Island study area. The geographical extent and type of activities involved in both cases were sufficiently similar to validate the use of these factor ratios or weightings in the Tocks Island area decision-making process.

The following tabulation represents the average opinion of the panel, rearranged mathematically to facilitate subsequent calculations.

<u>Factor</u>	<u>Relative Importance</u>
Implementation	23
Adaptability	13
Reliability	28
Cost	20
Social Benefits	16

Since there was a considerable range in the individual opinions on which these average values were based, two other sets of weightings were developed to show the effect of extreme rather than average values. These additional sets were derived, (after statistical evaluation of individual choices) from the 10 percent probability opinions and the 90 percent probability opinions.

<u>Factor</u>	<u>Relative Importance</u>	
	<u>10 Percent Probability</u>	<u>90 Percent Probability</u>
Implementation	19	28
Adaptability	14	12
Reliability	40	22
Costs	25	20
Social Benefits	2	18

The next step in the DARE analysis was to compare each of the five alternative approaches to liquid waste disposal for the purpose of estimating their relative capacity or ability to achieve the desirable effects of each of the five factors. To facilitate calculation the cumulative value of the 5 alternatives (for each factor) was set at 100, with the higher values indicating the more favorable alternative. This evaluation was made by 10 members of the staff

of ROY F. WESTON, including all those involved in the major technical and managerial aspects of this study. The panel's consensus is presented in the following tabulation:

	Alternative				
	<u>I</u>	<u>II</u>	<u>III</u>	<u>IV</u>	<u>V</u>
Implementation	34	28	18	12	8
Adaptability	10	12	26	26	26
Reliability	7	11	25	27	30
Costs	19	20	23	19	19
Social Benefits	10	14	23	26	27

The final step was to calculate an overall ranking for each Alternative. This was done for each alternative by multiplying the value in each factor by the weighting of that factor and then adding the five products. The results were as follows:

	<u>Average Factor Weighting</u>	<u>10% Probable Factor Weighting</u>	<u>90% Probable Factor Weighting</u>
Alternative I	1,648	1,561	1,786
Alternative II	1,732	1,668	1,846
Alternative III	2,280	2,327	2,204
Alternative IV	2,166	2,199	2,090
Alternative V	2,174	2,245	2,074

The consensus indicated Alternative III as the most favorable approach, whether average, 10 percent probability, or 90 percent probability factor weightings were used. Again, there was a considerable variation in the individual opinions making up the consensus. When the same calculation of the overall value was repeated for each panel member, the following favorability situations were indicated:

Average Factors Weightings - seven favored Alternative III, two favored Alternative V, and one favored Alternative IV.

10% Probability Weightings - six favored Alternative III, and two each favored Alternatives IV and V.

90% Probability Weightings - Five favored Alternative III, two each favored Alternatives II and IV and one favored Alternative V.

The overall effect of the DARE analysis is strong support for adoption of Alternative III as the approach for liquid waste disposal in the TIRES area.

SOLID WASTE DISPOSAL

Two basic methods of solid waste disposal are considered feasible for the TIRES area: sanitary landfill and incineration. Composting of solid wastes was considered, but subsequently eliminated as a practical approach to the disposal of solid wastes in the study area in the foreseeable future. Incineration would involve limited use of the sanitary landfill method for residue disposal. Consideration has also been given to the feasibility of hauling solid wastes out of the TIRES area for final disposal.

As a result of investigation and evaluation of these alternatives, sanitary landfill within the TIRES area is recommended as the best approach because:

1. Land areas suitable for use as sanitary landfills are within reasonable proximity of anticipated population concentrations.
2. The soils, geology, and topography of these areas are such that properly designed and operated sanitary landfills should not contaminate the surface- or ground-water resources.
3. Cost savings of \$2.75 per ton to \$5.50 per ton can be realized by utilizing the sanitary landfill method in preference to incineration.
4. Since land suitable for sanitary landfill is available in sufficient amounts within reasonable distances of anticipated population centers, and since the value of the land is no greater than that of comparable land outside the TIRES area, there is no economic justification for hauling waste out of the area for final disposal. This latter approach would incorporate a haulage cost into the total disposal cost and could be justified only if local landfill areas were not available at reasonable cost.

Improper location and operation of sanitary landfills must not be permitted, because of the basic danger of contamination of ground- and surface-water resources and of the overall environment. Areas selected as sanitary landfill sites should not be subject to flooding or excessive surface runoff. The results of soil and geologic studies must assure that leachate from a sanitary landfill does not percolate to ground and surface waters without proper and adequate natural treatment. To this end, the potential interaction between landfilled materials and ground and surface waters must be accurately defined prior to the selection of a site for use as a sanitary landfill. Detailed topographic, soil, and geologic data should be collected and analyzed for each potential site. In conjunction with basic data collection and analysis, surface- and ground-water hydrology and flow patterns will have to be identified and mapped to ensure against contamination.

The information presented in the previous sections and in the appendices of this report demonstrates clearly that solid waste management policy must, as one of its primary considerations, be concerned with the acquisition of enough land to accommodate the disposal of the projected solid waste production for a long period of time. The methods used in handling the wastes produced do not change this basic responsibility, because large land areas are required for disposal, no matter what process method is used. The incineration method leaves a residue of incinerator ash, unburnable products, and bulky wastes, which together require less land area for ultimate disposal than does sanitary landfill of all solid wastes; nevertheless, land requirements are still significant when incineration is used. Thus, delays in the early acquisition of adequate land for future solid waste disposal may ultimately place a community in the position of having to find disposal sites unreasonably distant from the area of waste generation. To suggest land

acquisition on a short-term basis with a view to hauling the residue ultimately to other areas in the future represents a basic flaw in policy.

While proposals being made today for some metropolitan areas to transport waste products by rail to fill strip mines or other unusable ground appear to be financially feasible, no demonstration of such a practice has been made, no actual costs are available, and legal and political constraints exist.

Since solid waste disposal has been found to be manageable under government supervision, it follows that government should reserve the land necessary for disposal sites before the impact of economic competition creates land values or other conditions which interfere with the necessary acquisitions. Land so reserved and owned can be used by the applicable government for solid waste disposal or can be leased under appropriate government contracts to private enterprise for the operation of waste disposal facilities. The decision between private or government operation can be a matter of local preference, or can be based upon the best cost attainable. But this freedom of choice does not exist with regard to the ability of private individuals to acquire and reserve land needed as future disposal sites.

The hope that composting of solid waste will resolve many of the solid waste disposal problems of today is not yet fulfilled. While the technology is available and has been demonstrated in pilot experiments, no plant operating free of nuisance has produced economic figures which compare favorably to the cost of landfill or incineration. Should composting become wide-spread and economically justified in the future, land will still be required for wastes that cannot be composted.

The present solid waste operations in the TIRES area do not demonstrate the existence of sufficient governmental regulation and enforcement action. This implies that further efforts in this area should look toward

improved laws and administrative techniques to ensure that sound solid waste disposal practices prevail. Without reasonably uniform policies among the states involved and the assurance that inspection systems are reasonably similar, the successful control of solid waste disposal facilities cannot be anticipated. Public policy should be directed at these areas of the management program at an early date to assure that the appropriate practices are developed along with the growth of the problem.

In summary, the comparison of disposal costs between incineration and landfill strongly favors disposal of solid waste by landfill within the study area. This use of land, where land can be recovered for future utilization as is the case with a sanitary landfill, offers a strong incentive for early detailed surveys to determine location and availability of the most suitable land for future landfill sites. Thus, detailed landfill site evaluation and a program of site acquisition should be undertaken as an essential part of the master plan. The extent of the land use for the landfill method of solid waste disposal indicates that short-range economies may be realized but also that they may lead to higher costs in the long run because of the scarcity of suitable sites. The detailed studies should cover all the factors significantly influencing land use so that rational long-range plans can be formulated.

The data presented in Section IV indicate an estimated total land requirement for sanitary landfill disposal of 11 square miles by the year 2020. This is subject to certain assumptions; for example, the total land requirement is a function of the depth to which the solid wastes will be compacted to reduce their volume. Other assumptions, relative to quantity, production, compaction, and depth of fill, however, do not obviate the need to consider early acquisition of land for the disposal of solid wastes generated in the years ahead.

VI

FIGURES

-123-

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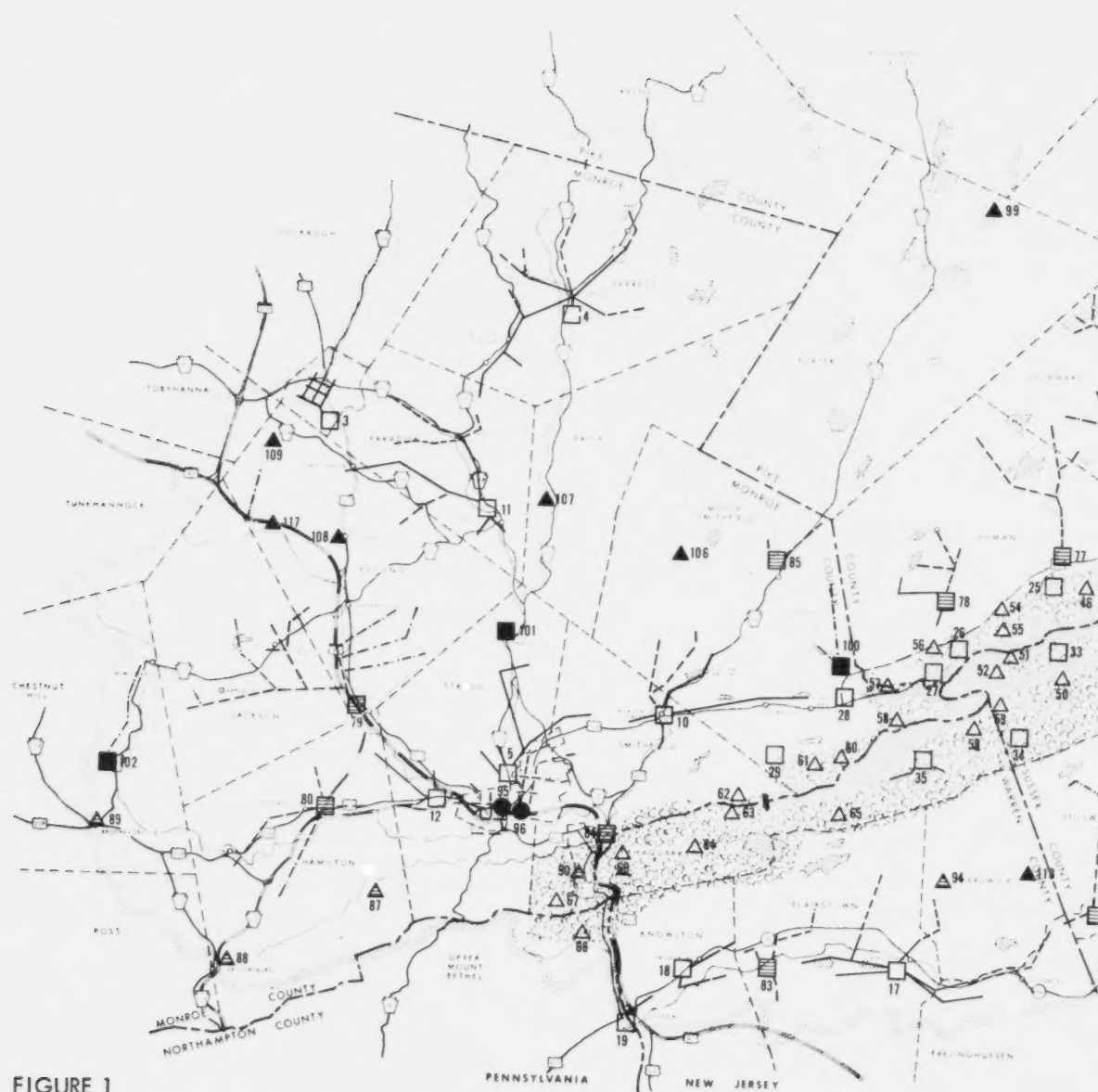
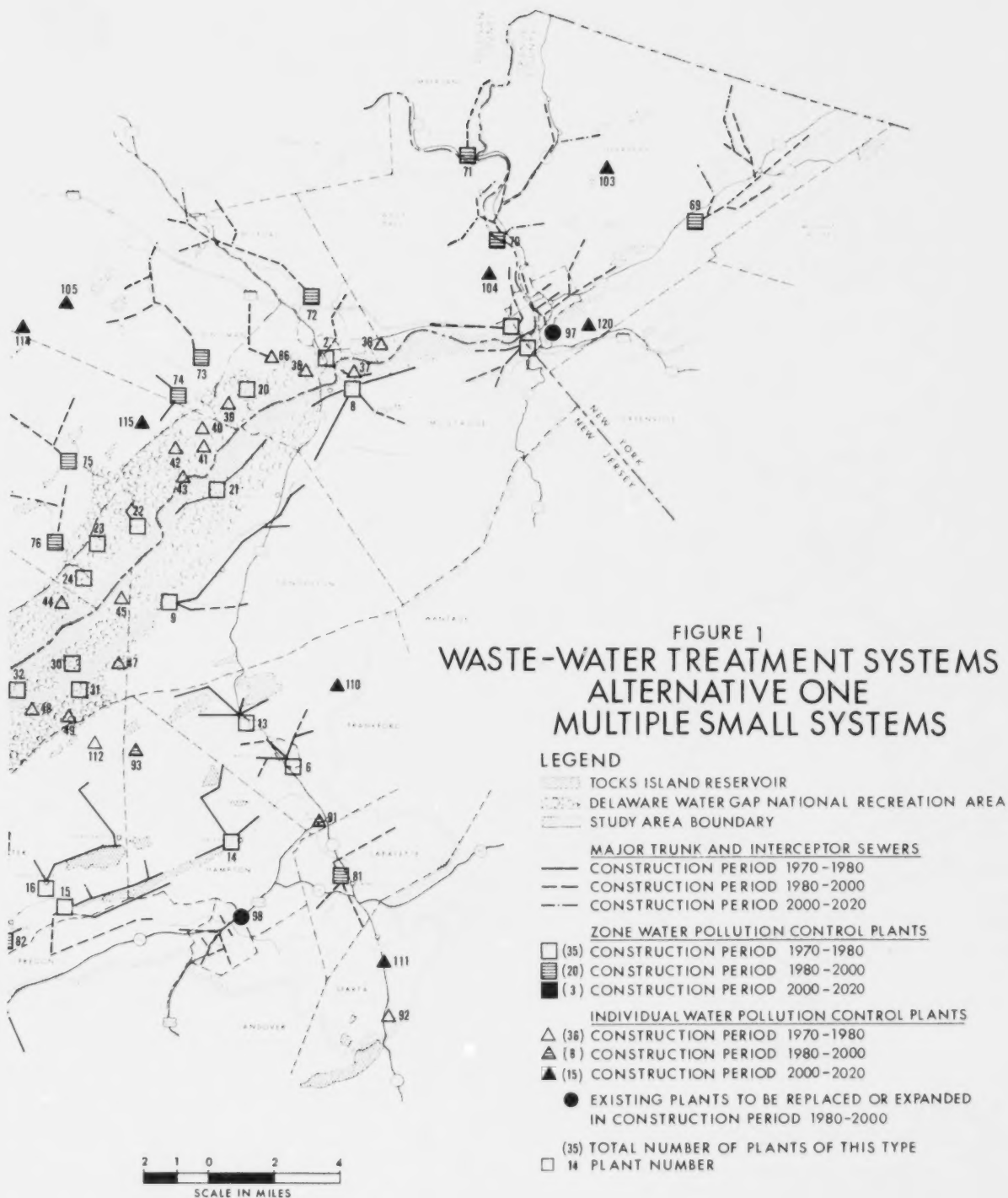


FIGURE 1
DELAWARE RIVER BASIN COMMISSION

THIS PROJECT WAS SUPPORTED IN PART BY A
DEMONSTRATION GRANT, NUMBER WPD-136,
FROM THE RESEARCH AND TRAINING GRANT
PROGRAM, FEDERAL WATER POLLUTION CONTROL
ADMINISTRATION



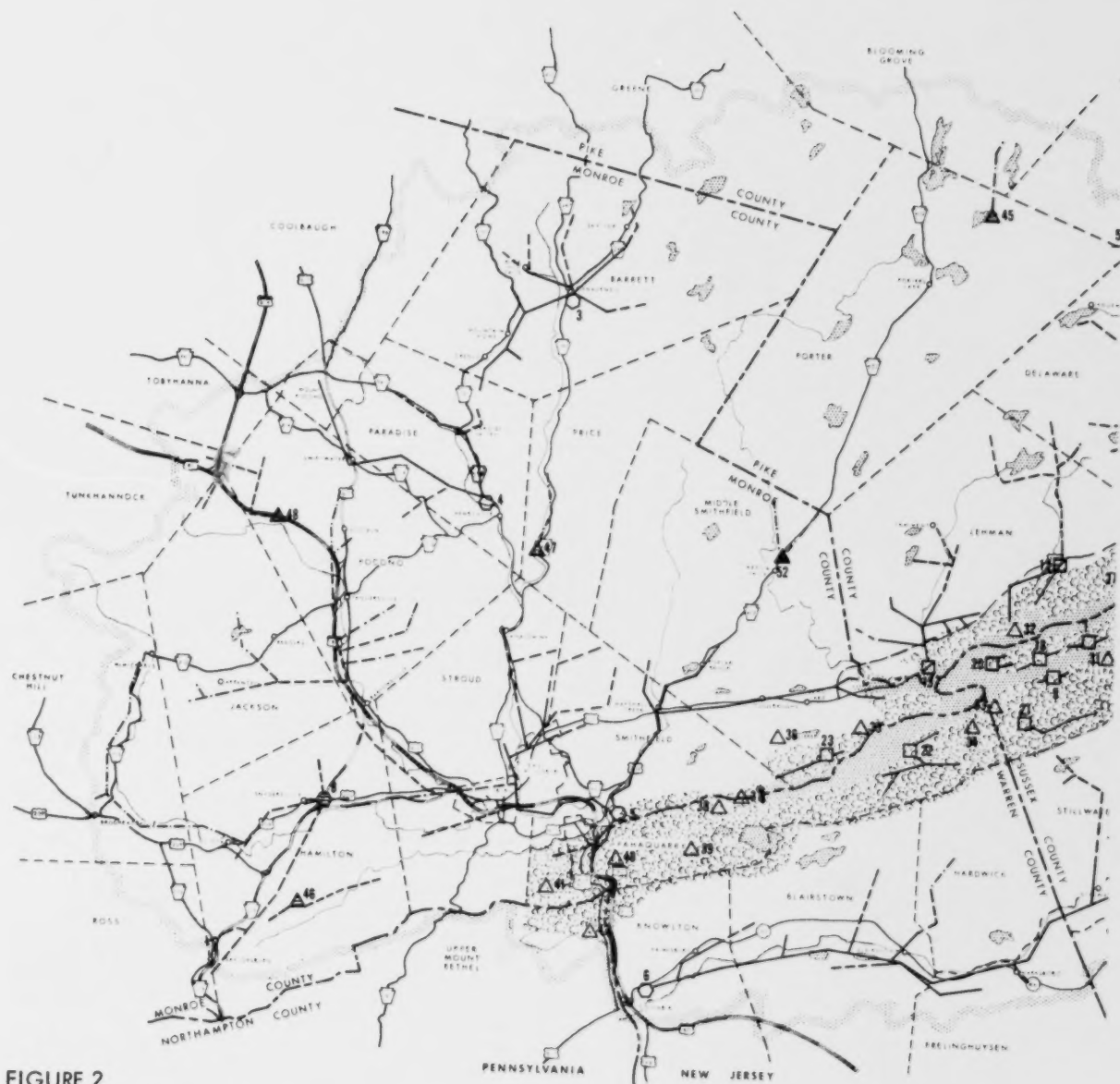


FIGURE 2
DELAWARE RIVER BASIN COMMISSION

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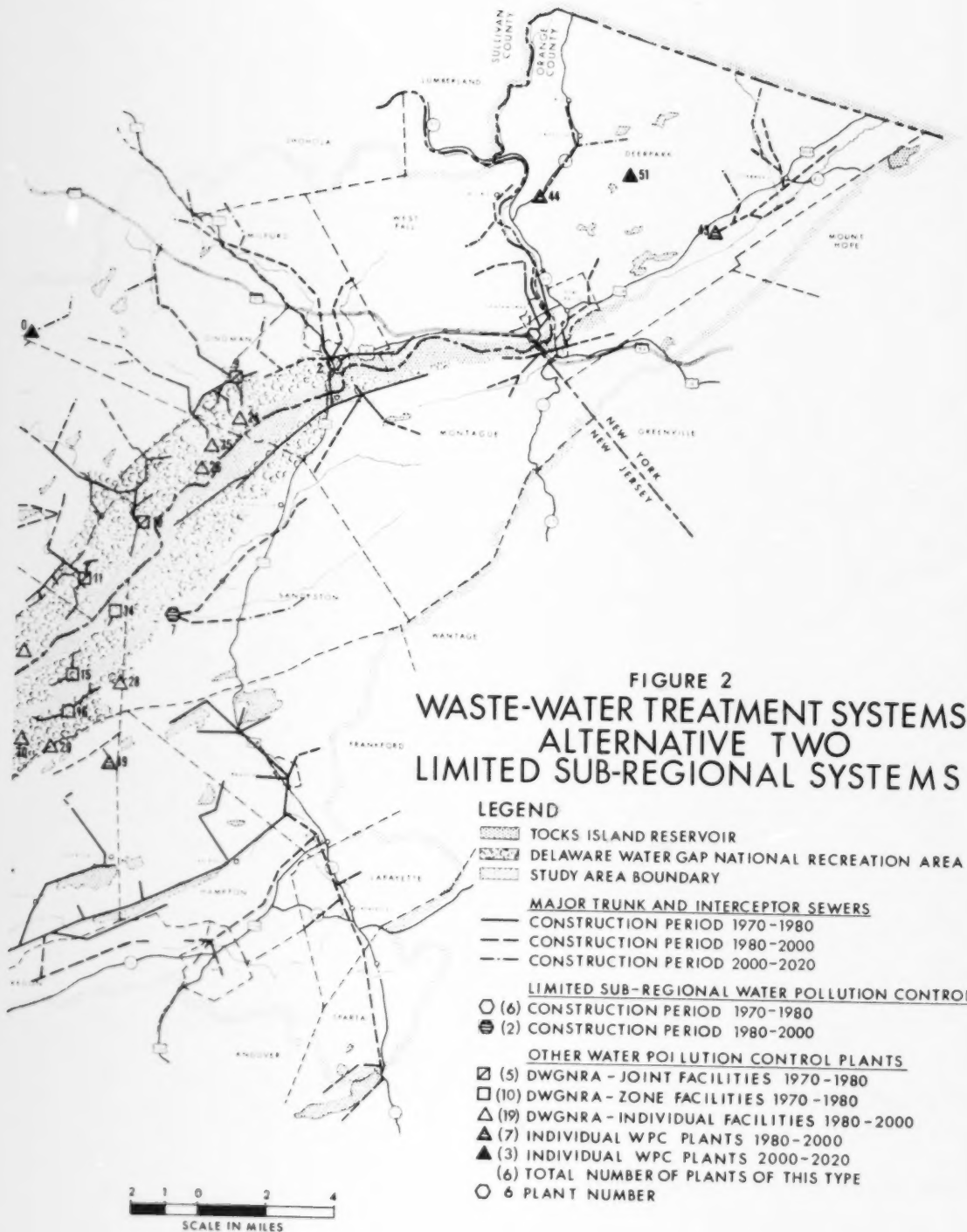




FIGURE 3
DELAWARE RIVER BASIN COMMISSION

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ADMINISTRATION.



FIGURE 3
WASTE-WATER TREATMENT SYSTEMS
ALTERNATIVE THREE
SUB-REGIONAL SYSTEMS

LEGEND

- TOCKS ISLAND RESERVOIR
- ▨ DELAWARE WATER GAP NATIONAL RECREATION AREA
- STUDY AREA BOUNDARY

- 1 MATAMORAS WPCP
- 2 MILFORD WPCP
- 3 FLAT BROOK WPCP
- 4 UPPER BRODHEAD WPCP
- 5 LOWER BRODHEAD WPCP
- 6 PAULINS KILL WPCP

MAJOR TRUNK AND INTERCEPTOR SEWERS

- CONSTRUCTION PERIOD 1970-1980
- - - CONSTRUCTION PERIOD 1980-2000
- CONSTRUCTION PERIOD 2000-2020

ZONE WATER POLLUTION CONTROL PLANTS

- CONSTRUCTION PERIOD 1970-1980

INDIVIDUAL WATER POLLUTION CONTROL PLANTS

- △ CONSTRUCTION PERIOD 1970-1980
- △ CONSTRUCTION PERIOD 1980-2000
- ▲ CONSTRUCTION PERIOD 2000-2020

2 1 0 2 4
SCALE IN MILES

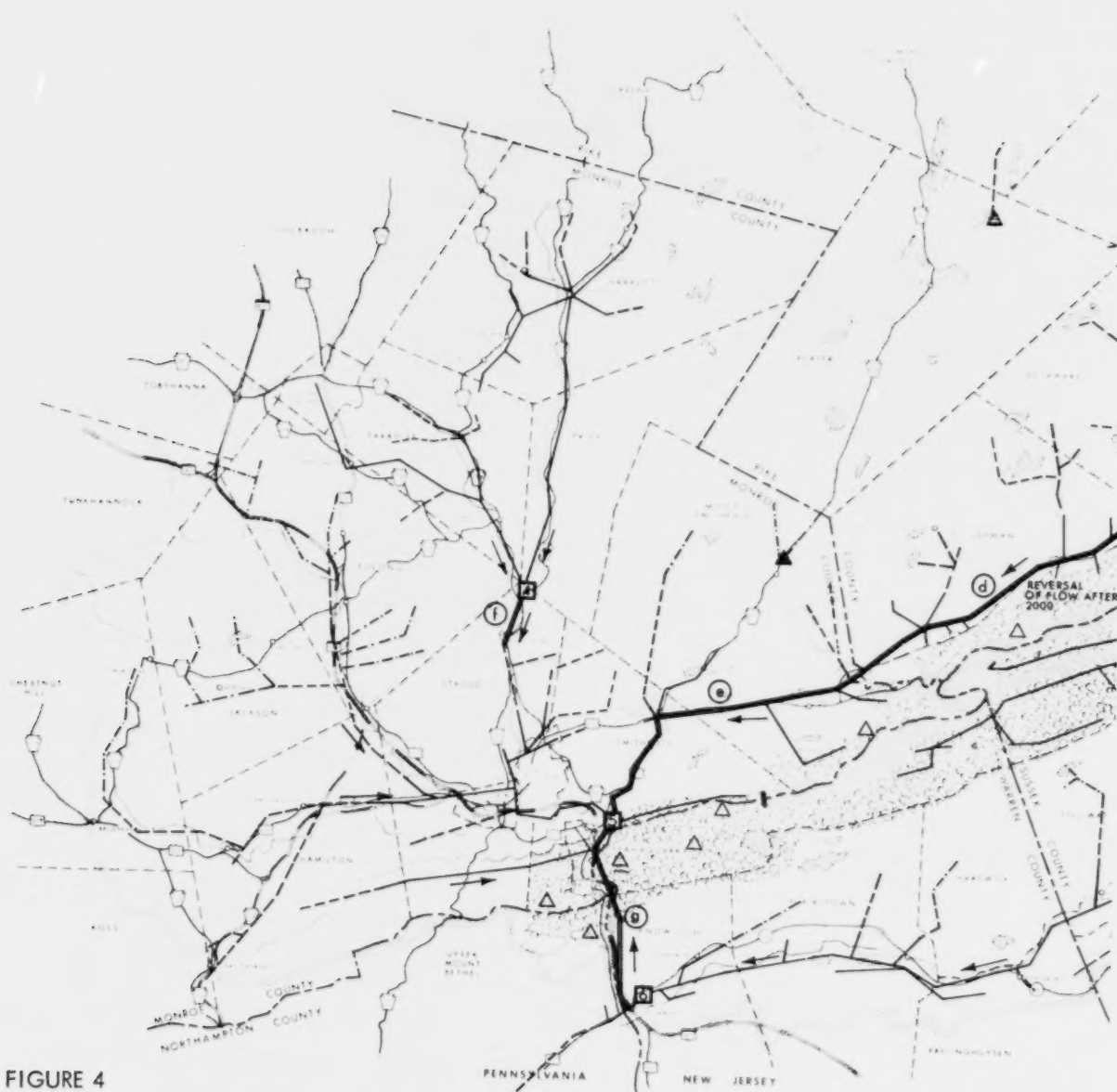
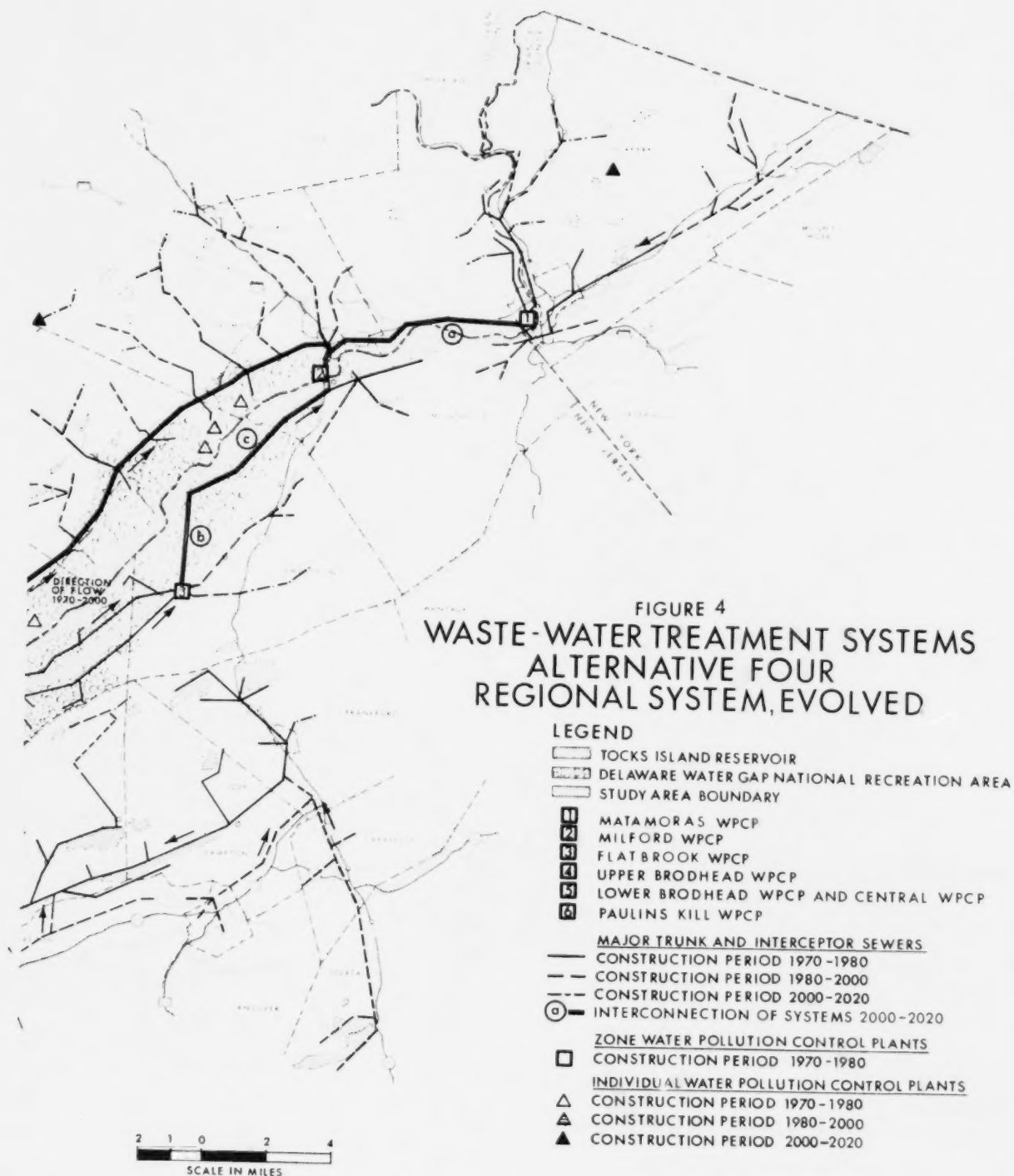


FIGURE 4
DELAWARE RIVER BASIN COMMISSION

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ADMINISTRATION





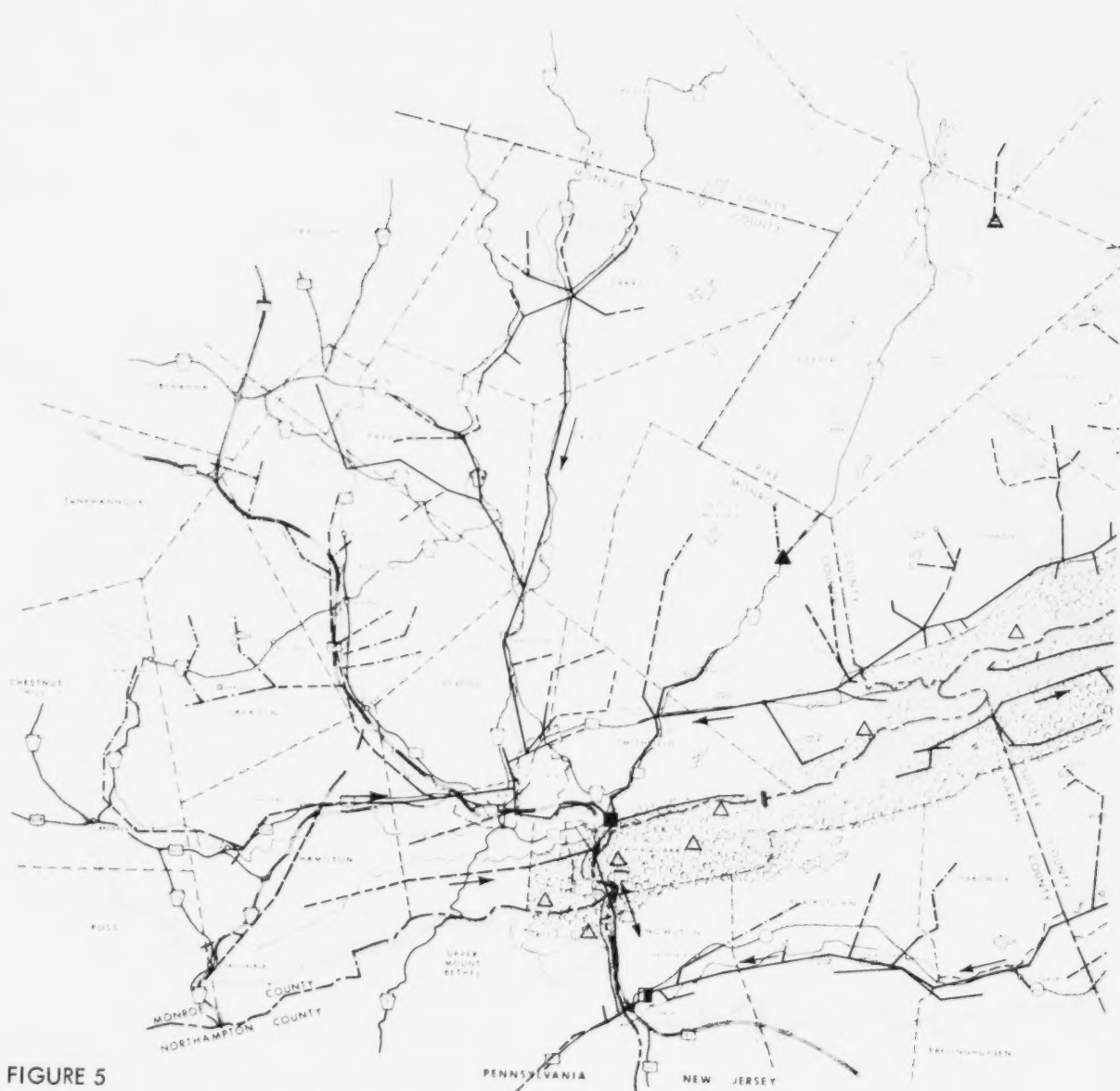
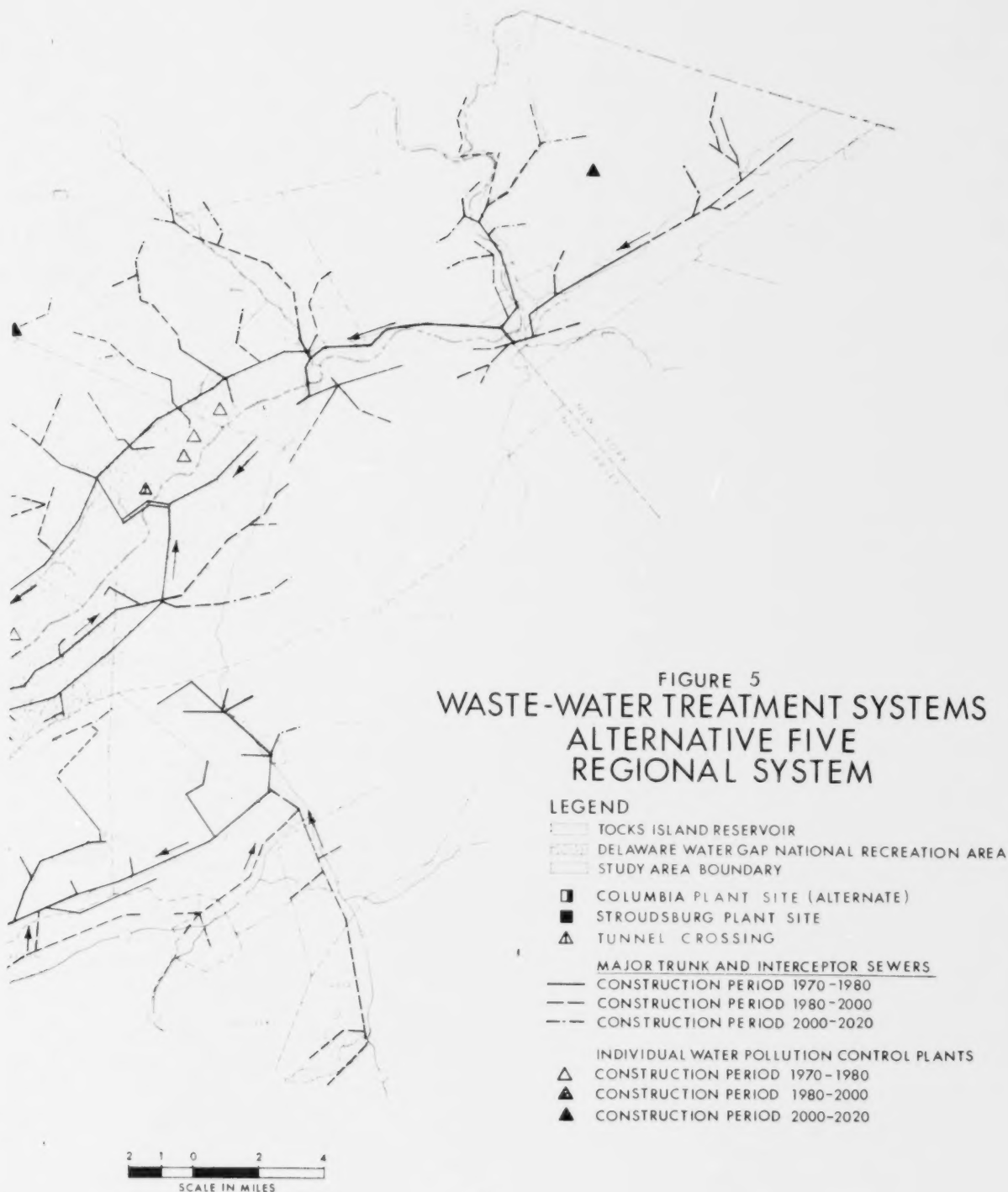


FIGURE 5
DELAWARE RIVER BASIN COMMISSION

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FROM THE RESEARCH AND TRAINING GRANT
PROGRAM, FEDERAL WATER POLLUTION CONTROL
ADMINISTRATION.



TOCKS ISLAND REGION
ENVIRONMENTAL STUDY

APPENDICES A THROUGH I

April 1970

W.O. 256-03

Prepared by
ROY F. WESTON
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West Chester, Pennsylvania

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APPENDIX A

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APPENDIX B

TWO SAMPLE LAND AREA CONVERSION TABLES
FOR POPULATION ALLOCATIONS

COMPLETE APPENDIX AVAILABLE
AS OPEN FILE DATA
FROM DRBC

Index	Major Drainage Basin			Sub-Drainage Basin		Sub-Drainage Basin Division				Name	M i n o r	
				No.	Total Acres	No.	Total Acres	Non-Usable Acres	Net Usable Acres		Gross Area	
	Acres	Sq.Mi.										
P0-1-1	Pocono	PO	105,406	1	35,517	1	21,874	9,920	11,954	Delaware Twp.	29,033	45.4
P0-1-2				↓	↓	2	12,544	6,080	6,464	Lehman Twp.	31,400	49.0
P0-1-3				↓	↓	3	1,099	256	843	Dingman Twp.	36,480	57.0
P0-2-1				2	18,460	1	15,854	3,456	12,398	Dingman Twp.	36,480	57.0
P0-2-2				↓	↓	2	2,128	1,600	528	Delaware Twp.	29,033	45.4
P0-2-3				↓	↓	3	478	---	478	Shohola Twp.	28,672	44.8
P0-3-1				3	16,250	1	6,181	896	5,285	Milford Twp.	7,852	12.3
P0-3-2				↓	↓	2	6,360	1,728	4,632	Dingman Twp.	36,480	57.0
P0-3-3				↓	↓	3	1,405	1,088	317	Westfall Twp.	20,032	31.3
P0-3-4				↓	↓	4	2,129	256	1,873	Shohola Twp.	28,672	44.8
P0-3-5				↓	↓	5	175	---	175	Milford Boro	276	0.4
P0-4-1				4	17,191	1	692	512	180	Shohola Twp.	28,672	44.8
P0-4-2				↓	↓	2	14,194	2,368	11,826	Westfall Twp.	20,032	31.3
P0-4-3				↓	↓	3	1,671	320	1,351	Milford Twp.	7,852	12.3
P0-4-4				↓	↓	4	101	---	101	Milford Boro	275	0.4
P0-4-5	↓	↓	↓	↓	↓	5	533	---	533	Matamoras Boro	533	0.8

Civil Division					Name	County				% for Population Allocation
Area in Study Area		% of C.D.		Usable Acres		In				
Acres	Sq.Mi.	Study Area	SDBD			Total		Study Area		
						Acres	Sq.Mi.	Acres	Sq.Mi.	
29,033	45.4	100.0	74.8	17,513	Pike	349,056	545.4	170,335	264.9	68.2
31,400	49.0	100.0	40.9	19,816						32.6
26,833	41.0	71.6	2.9	27,269						3.1
26,833	41.0	71.6	42.3	27,269						45.3
29,033	45.4	100.0	7.3	17,513						3.0
3,299	5.1	11.5	1.0	19,972						2.4
7,852	12.3	100.00	74.9	6,640						79.7
26,833	41.0	71.6	16.9	27,269						16.9
15,599	24.4	77.8	7.0	16,320						1.9
3,299	5.1	11.5	10.3	19,972						9.4
276	0.4	100.0	54.5	276						63.4
3,299	5.1	11.5	0.2	19,972						0.9
15,599	24.4	77.8	70.9	16,320						71.1
7,852	12.3	100.0	24.4	6,640						20.9
275	0.4	100.0	40.4	275						36.7
533	0.8	100.0	100.0	533	↓	↓	↓	↓	↓	100.0

Index	Major Drainage Basin			Sub-Drainage Basin		Sub-Drainage Basin Division				Name	Minor	
				No.	Total Acres	No.	Total Acres	Non-Usable Acres	Net Usable Acres		Gross Area	
	Name	Code	Acres								Acres	Sq.Mi.
P0-5-1	Pocono	P0	105,406	5	18,088	1	18,240	320	17,920	Deerpark Twp.	43,904	67.6
P0-5-2	Pocono	P0	105,406	5	18,088	2	394	---	394	Pt. Jervis City	1,799	2.8
BU-1-1	Bushkill	BU	106,166	1	62,654	1	3,062	448	2,615	Smfld. Twp.	14,700	23.0
BU-1-2						2	14,527	3,240	10,417	Mid Smfld. Twp.	33,303	51.1
BU-1-3						3	4,692	384	4,308	Barrett Twp.	33,617	51.5
BU-1-4						4	3,921	1,792	2,129	Price Twp.	16,256	25.4
BU-1-5						5	19,762	8,396	10,866	Porter Twp.	37,215	58.2
BU-1-6						6	7,888	128	7,760	Greene Twp.	37,440	58.5
BU-1-7						7	6,825	3,392	3,433	Blm Grove Twp.	47,488	74.2
BU-1-8				↓	↓	8	2,027	1,637	390	Dingman Twp.	36,480	57.0
BU-2-1				2	21,785	1	710	---	710	Mid Smfld. Twp.	33,308	51.1
BU-2-2						2	11,916	7,936	3,980	Porter Twp.	37,215	58.2
BU-2-3						3	9,072	2,432	6,640	Lehman Twp.	31,400	49.0
BU-2-4				↓	↓	4	87	87	0	Dingman Twp.	36,480	57.0
BU-3-1				3	21,682	1	1,375	640	735	Dingman Twp.	36,480	57.0
BU-3-2	↓	↓	↓	3	21,682	2	5,537	4,966	571	Porter Twp.	37,215	58.2

KEY

Pt. Jervis - Port Jervis
Smfld. - Smithfield
Mid Smfld. - Middle Smithfield
Blm Grove - Blooming Grove

Civil Division					County					
Area in Study Area		% of C.D.		Usable Acres	Name	Total		In Study Area		% for Population Allocation
Acres	Sq.Mi.	Study Area	SDBD			Acres	Sq.Mi.	Acres	Sq.Mi.	
43,826	68.6	100.0	40.0	42,170	Orange N.Y.	530,560	829.0	51,042	80.9	42.6
1,092	2.3	100.0	27.5	1,799	Orange N.Y.	530,560	829.0	51,042	80.9	21.9
14,000	23.0	100.0	23.0	12,374	Monroe	390,400	610.0	227,998	347.8	21.1
33,308	52.1	100.0	42.8	26,586	Monroe	↓	↓	↓	↓	39.3
33,617	52.5	100.0	14.2	28,824	Monroe	↓	↓	↓	↓	15.4
16,256	25.4	100.0	26.2	9,604	Monroe	↓	↓	↓	↓	22.2
37,215	58.2	100.0	52.1	15,417	Pike	349,056	545.4	170,335	264.9	70.3
11,239	17.6	30.1	21.0	32,000	Pike	↓	↓	↓	↓	24.2
6,824	10.7	14.4	14.4	30,016	Pike	↓	↓	↓	↓	11.4
26,833	41.0	71.6	5.4	27,269	Pike	↓	↓	↓	↓	1.4
33,308	52.1	100.0	0.2	26,586	Monroe	390,400	610.0	227,998	347.8	2.6
37,215	58.2	100.0	31.4	15,417	Pike	349,056	545.4	170,335	264.9	25.8
31,400	49.0	100.0	28.8	19,816	Pike	↓	↓	↓	↓	33.5
26,833	41.0	71.6	0.2	27,269	Pike	↓	↓	↓	↓	0
26,833	41.0	71.6	3.6	27,269	Pike	↓	↓	↓	↓	2.7
37,215	58.2	100.0	14.6	15,417	Pike	↓	↓	↓	↓	3.7

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APPENDIX C

EXISTING DEVELOPMENT PATTERN

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Existing Land Use Map

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APPENDIX C

EXISTING DEVELOPMENT PATTERN

The Tocks Island area is beginning to emerge as an identifiable region today. Its history is one of divergent activities of all kinds associated with early pioneering and land settlement. Its future is rooted to those historic characteristics and events, but places new emphasis on the increasing importance of modern life and its recreational and cultural needs, integrated into a distinct region under the pervasive influence of the Tocks Island projects.

Land use

The study of existing land uses is one means of analyzing the emergence of the area and of determining the directions of future development. The generalized regional land-use map, shown as Figure C-1, describes the settlement patterns and use of the TIRES area at the present time. At this regional level, the general identification of types of land use serves as a statement of the unique characteristics of the region. By noting the aggregations of development in urban centers, villages, and other places and by showing the presence and extent of various uses in these areas, subregional relationships and historic growth patterns become evident.

By further analysis, the general choices made in locating particular land uses can be identified. The relationships among transportation facilities, existing development, and the physical features of the land, indicate where and why land development did or did not take place. Supplemented by economic and population studies, conclusions may be drawn regarding those land uses that will continue to grow, those that take on new significance, and those areas that are likely to be developed in the future.

The land-use map focuses on seven major characteristic groupings including residential, industrial, commercial, resort, recreational, public (and quasi-public), and agricultural land-use activities. It takes into account two distinctive qualities of land use: intensive use (development of land in a built-up sense), and extensive land use (as characterized by open areas). The land uses of the latter group are the camps, parks, state forests and gamelands, farms, resort land holdings, watersheds, and hunting club lands, which require large areas for their activity and which contribute to the "open space" quality of the region. They exist as characteristic land uses in the region and serve as a statement of the area's unique regional functions. Thus, the present relationship of the TIRES area to other regions and distant urban areas is clearly suggested by: large tracts

of land retained to protect water supply; rural land used for farming and similar purposes; and extensive major resort tracts, game lands, forests, parks, and camps that provide outdoor recreation opportunities to nearby metropolitan residents.

These "open space" or low-density uses point to the primary asset of the region--natural amenity. Serving a wealth of functions, from recreational activities and resource utilization to local employment, their protection and development are of primary importance and concern to both private and public organizations and individuals. The forested landscape and other natural resources are principal assets of the resort, agriculture, housing, sport and other recreational industries, and, on a much smaller scale, the local mining and power industries.

Although the presence of these uses is a unique characteristic of the region, they are, individually, typical uses of rural areas. Of distinct note, however, are the hunting and fishing club land holdings. Absent from the TIRES area in New Jersey (where local farmers open their lands to hunting groups), they are noted in New York and throughout the Pennsylvania portion of the study area. With the 26,000-acre Blooming Grove Hunting and Fishing Club dominating the group, their holdings almost double the broad ownership of state lands. In Monroe County, several streams are bordered by large fishing club properties that prevent encroachment and possible impairment by other uses. The incorporation of many of these clubs under state charters that restrict development uses contributes to their protection of open space and continuation into the future.

The developed land pattern represents the urbanizing forces in the region. The commercial category contains retail trade and services but excludes recreational and overnight accommodation services, which appear in the resort group. This attempts to distinguish between those commercial activities that primarily serve the population living within the region, and those activities oriented to the region's function as a recreation and resort area.

The public (and quasi-public) group includes institutions in one subgroup and watershed functions in the other. Watershed areas for municipal water supplies and those of utility companies are indicated and contribute to the open space quality of the area. In the institutional subgroup, municipal buildings, schools, colleges, fire stations, cemeteries, hospitals, nursing homes, churches, and the like are enumerated and offer a measure of the urban character of the region.

Consideration of the institutional subgroup and the commercial uses permits a ranking of various developed areas. The presence of these uses as found in Newton, the Port Jervis-Matamoras area, and

the Stroudsburgs suggests their status as regional centers. The limited presence of these uses in places such as Swartswood, Stillwater, Mildrift, Bushkill, Dingmans Ferry, Marshalls Creek, Canadensis, Cresco, Tannersville, Bartonsville, Analomink, and Brodheadsville suggest a village-type character.

By comparing these aggregations and noting their development patterns, villages are characterized by older housing; local centers are gaining some recent housing and the regional centers are making noticeable gains in new development. With the presence of commercial and institutional uses acting as a force of concentration, one may conclude that the present rise of the regional centers should lead to their continued growth as urban aggregations.

At the same time, there are opposite trends in commercial development which point to the breaking up of the patterns of aggregation. Major highway routes, particularly in New Jersey, are being subjected to the development of commercial establishments quite different from those customarily serving travelers. This growing category of establishments, ranging from supermarkets to automobile dealerships are oriented to subregional market areas. Because new areas, formerly remote, are satisfactory for residential development, shopping patterns and service areas are changing.

The commercial resort uses, because of their significance, have been given special attention. One subgroup contains hotels, motels, lodges, and the like, which cater to the tourist population. A second subgroup designates camps which, while of a quasi-public nature, are associated with resort activities. The present focus of the resort industry is in the famous Poconos, where the biggest resorts are concentrated. The resorts are found throughout Monroe County with a total of 190 in the study area. In Pike County the relatively few resorts are concentrated in Lehman Township, Dingmans Ferry, and Milford Borough with others randomly located off Route 209 as it follows the Delaware River northward. Other land uses of this type are found in the Port Jervis area and in the Neversink Valley. There are few resorts in New Jersey but none as significant as those in Pennsylvania. Camps are widely dispersed throughout the study area, with most in Pennsylvania. Ranging in area from 100 acres to 4,000 acres, they may have as many as 700 campers and counselors in daily attendance.

The industrial group consists of all manufacturing, wholesaling, and extractive industry operations. The heaviest concentrations of industry are found in Port Jervis and the Stroudsburgs, where the presence of the railroads has exerted a major influence. Newton is far less industrialized. Outside of these regional centers, industrial uses are widely dispersed. Somewhat random locations along rail lines and highways are found in Monroe, Warren, and Sussex Counties and paralleling the Neversink River in Deerpark Town.

The residential group indicates urbanization through housing development and, as such, consists of all permanent and seasonal non-farm dwellings, whether mobile homes, one-family detached, or multiple-family units. It should be noted that the individual dwelling, prevalent in rural areas, cannot be indicated at the regional scale, and only the aggregations of residential uses have been shown.

Analysis of this important category was supplemented by a study of all platted subdivisions in the TIRES area. By going beyond existing development, a more conclusive indication of the growth trends in the area is gained. Subdivisions as large as 935 acres (3,500 lots) were mapped, ranging in densities from 1/8-acre lots to 6 1/2-acre lots and differing in kind from the year-round residence suburban type to the second-home recreational type. In all, a total of 237 subdivisions containing over 58,000 lots were mapped and tabulated.

While some of the subdivisions may never be developed, subdivision activity exerts a major urbanizing force in itself. Generally, the medium-density, year-round type development will locate near the regional centers of Newton, Port Jervis, and the Stroudsburgs. This type is generally seen developing radially along the roads leading from these centers.

The second-home or recreation-type subdivision was found to be dispersing throughout the region. Attracted to lake sites and rugged, scenic areas, these subdivisions represent a trend toward dispersion. Proximity to existing centers providing services and facilities seems to be far less a factor than the attraction of areas which lend themselves to outdoor recreation. Noting the explosive growth in seasonal housing units from 1950 to 1960 for the counties of the study area (Table C-1 following), the possible dominance of this development type, especially in Pennsylvania, suggests that patterns of concentrated and contiguous development close to existing centers may give way to development that is scattered. To combat random scattering, the attraction of lakes may act to bring about systems of lake-side communities and villages.

The seasonal nature of all housing in the study area was investigated through data from the 1960 Census of Housing.⁽¹⁾ Table C-2

⁽¹⁾ Unpublished housing data found in Table PH-1, Population and Housing Characteristics: 1960, were used to develop seasonal occupancy information. The "other vacant" category of housing units was used to represent seasonal or second homes because only units not available on the housing market, comprising all of these units and in the resort areas the housing units reserved for the occupancy of summer workers, are included in this group. Other units that would be included in this group such as units held vacant because of litigations, the settlement of estates, or reserved for the use of migratory workers are viewed as insignificant. Units vacant for other reasons, such as the temporary absence of the owner (enumerated as occupied), units vacant and unfit for human habitation or condemned (excluded from the inventory altogether), and all newly constructed or other units available for sale or rent (listed as "available vacant") are not included. Finally, where a housing unit is found to be occupied at the time of the census by seasonal residents, wherein the unit is not their usual place of residence, the unit is enumerated as "other vacant".

TABLE C-1
SEASONAL AND YEAR-ROUND
HOUSING UNIT GROWTH 1950-1960,
TIRES AREA COUNTIES

<u>County</u>	<u>Percent Increase Seasonal Housing Units</u>	<u>Percent Increase Year-round Housing Units</u>
Orange	82.8	24.4
Pike	136.8	14.1
Monroe	52.2	24.7
Sussex	49.5	43.3
Warren	33.6	20.7
Northampton	127.1	19.0

Source: Census of Housing: 1950 and 1960.

TABLE C-2
SEASONAL AND YEAR-ROUND
OCCUPIED HOUSING UNITS, 1960,
TIRES AREA COUNTIES

<u>County</u>	<u>Seasonal Housing Units</u>	<u>Year-Round Housing Units</u>	<u>Ratio Seasonal to Year-Round</u>
Orange	575	4,024	.14
Pike	2,355	1,975	1.19
Monroe	5,235	10,359	.51
Sussex	3,045	4,428	.69
Warren	<u>271</u>	<u>1,069</u>	.25
Study Area Totals	11,481	21,855	

shows the estimated seasonal and year-round occupied housing units in the TIRES area for each county except Northampton which was excluded because it is a very small portion of the study area. The data show that there are more than half as many seasonal units as year-round. In Sussex County, the 3,045 seasonal housing units are considered generally to be second-homes. Although the percentage of seasonal units in Monroe and Pike used to house seasonal resort employees is undetermined, most employees are housed in "group quarters", leaving only a few to occupy seasonal units.

New Jersey.--The sub-areas of the New Jersey region are predominately rural-farm in character. A vast wooded band follows the Kittatinny Ridge, paralleled by a broad band of farmland in the eastern valley. Numerous camps and second-home communities dot lake sites in the foothills, and urban development follows strip settlement patterns along Routes 46, 94, 15, and 206. Elsewhere, pockets of development are found clustering at local crossroads. Newton is the dominant center, surrounded by and generally related to a triangle of the local centers of Blairstown, Branchville, and Sparta.

Twenty-three percent of Warren County and 43 percent of Sussex County lie in the study area. A large percentage of this land is found in the Worthington and Stokes State Forests, High Point and Swartswood State Parks, and other public land holdings including many State "Green Acres" acquisitions. Other open lands are used by camps in Warren and in Sussex Counties, with some camps as large as 400 acres. Over 50 percent of the land in Warren and 30 percent in Sussex is in agricultural use. Of the 60 lakes in Sussex and 20 in Warren that are over five acres in surface area, there are 29 in Sussex and only two in Warren that have housing developments. Nine lakes are used by one or more camps, and the others are used for public and private recreation, power generation, water supply, flood retention, and farm purposes. Using as an example the Lake Hopatcong development experience just to the east of the study area, the development potential of these lakes is clear, and the threat of water pollution under present liquid-waste disposal practices is very real.

Typical lot sizes range from as small as 6,000 square feet to one-acre lots in the lake developments, to as high as three-acre lots elsewhere. However, with the practice of double-lot purchases in the smaller lot developments, houses are estimated to be developing at the rate of two to four units per acre, with one-acre lots typical of many areas. There is also an occasional two and three-acre lot development. The vast majority of housing units are the one-family detached type. The recent apartment developments in Newton, and mobile homes and various other housing types are present also, but in insignificant numbers.

Commercial uses are found in the shopping areas of Newton, Blainstown, and Branchville. Elsewhere, they dot state and county roads at random and form small clusters in places such as Columbia, Hainesburg, Marksboro, Stillwater, Swartswood, Ross Corner, Lafayette, Culvers Gap, Hainesville, and Montague. These roadside commercial uses, particularly the older establishments, have been local-serving in character. Some are oriented to the traveler trade. Recently commercial development located along highways has grown sufficiently to compete in sub-regional markets.

Small industrial areas are found in Newton and Branchville and in a few instances along Route 94. Large limestone mining operations are found to the east of Newton along the Lehigh and Hudson Railroad line in Sparta and Andover Townships.

Pennsylvania and New York.--Outdoor recreation is the principal use of most of the TIRES area land in Pennsylvania and New York. The rugged, forested terrain with swift-running streams and abundant lakes is the setting for many camps, resorts, recreation communities, hunting and fishing clubs, and other recreation areas.

Fifty-six percent of the land area in Monroe County and 49 percent of Pike lie in the study area, with about ten percent of Orange County and only one percent of Northampton County. The Delaware State Forest is the largest of the vast acreages of state forest and game lands. Additional forested lands include over 40,000 acres of hunting and fishing club lands, eleven separate watershed holdings, sixty-eight camps, and extensive major resort holdings. In Pike County, agricultural uses are limited to the flood plain along the Delaware River. In Monroe County, farming is scattered throughout the lower half of the County, and is the predominating land use in the southern end.

The Stroudsburgs and the Port Jervis - Matamoras area are the major urban concentrations and are viewed as major centers which create a developing corridor along Route 209. Local centers along this corridor are Bushkill, Dingmans Ferry, and the Borough of Milford. The Stroudsburgs contain a balanced mixture of uses and are developing radially along Routes 209, 447, 611 and 115. Port Jervis is an old railroad town containing the yards of the Erie-Lackawanna Railroad. Its central business district and intensive manufacturing uses crowd the old city. Recent land development, especially housing, extends along Routes 209, 97 and 42, far into Deerpark Town.

The Pocono area of Barrett Township constitutes another major development area. With many established resorts located in the vicinity, development has resulted in a network of local centers and villages. Cresco, Mountainhome, Buck Hill Falls, Canadensis, and Skytop comprise this network, within which commercial and residential uses are developing along Routes 191, 447, and 390.

2

Numerous other villages dot this sub-area. In New York, Cahoonzie and Cuddlebackville are local centers along the radial development extending into Deerpark Town. Mildrift on the Delaware River above Matamoras and the villages of Dingmans Ferry, Egypt Mills, and Bushkill on Route 209, comprise the few communities in Pike County. In Monroe County, besides the villages in the Pocono area, other villages have developed at the crossroads of the highway system outside the Stroudsburgs. The travel corridors of U.S. Route 611, Interstate 80, and Routes 115 and 209 typify the extended radial of routes outward from the Stroudsburgs along which small communities have grown.

New residential construction is highly active in Monroe and Pike Counties. A total of 118 subdivisions were tabulated recently in Monroe County, and 41 in Pike County. Pike County had the largest subdivisions, totaling over 35,500 lots, and Monroe County's total is in excess of 13,500 lots. In Monroe County, concentrations of residential uses are found in the Stroudsburgs and in the Pocono area. Existing residential development and platted subdivisions are located within or in proximity to the highway and village corridor developments mentioned above. A few residential developments are scattered elsewhere within the County. The typical lot in the Stroudsburg area ranges from 1/4 to 1/2 acre in size. In the Pocono area, the 1/2 acre lot is typical; elsewhere, lot sizes range from 1/8 acre to 6 1/2 acres. All residential developments are small to medium in size, ranging from 2 to 440 acres in total area. The year-round type is generally found in the Stroudsburgs, while the second-home or vacation type is prevalent elsewhere.

In Pike County, the predominant type of development is the recreation community. Vacation homes are being built at high rates at natural and man-made lake sites and are demonstrating the intensive interest in the outdoor recreation opportunities they offer. Some projects contain large, open, land holdings of their own. Others are located in close proximity to state forests and game lands. The existence of state and hunting club lands has limited the amount of available land for development to a broad band above and along the Delaware River. These developments are scattered throughout this band but are located generally on the slopes and plateau northwest of the villages of Bushkill, Egypt Mills, and Dingmans Ferry and the Borough of Milford. The one-third acre lot is typical; however, in grouping the houses, the gross density of development is much lower.

In Orange County, residential uses are found in and around Port Jervis, and are extending into Deerpark Town, primarily as strip development along Routes 209, 97, and 42. These routes parallel the Neversink River, Delaware River, and Shingle Kill respectively. A few lake site developments are evident; the Hawthorne Lake Development located off Route 6 is the largest. Scattered single residences are

also found in the Town. Housing construction has been moderate, and relatively few new homes are seasonal in Deerpark in comparison to Monroe and Pike Counties.

Most townships have a high ratio of seasonal to year-round housing units, while the cities and boroughs have a low ratio. The typical housing unit is the one-family detached dwelling. Mobile homes are present throughout the region, either on individual lots or in mobile home courts, and a few apartment buildings are located in the Stroudsburgs and in Port Jervis.

In the Pennsylvania-New York area, most commercial uses are situated in the regional centers, local centers, and villages. Visitor-serving highway commercial uses are spread along Routes 209, 611, and the 447-196 route between Stroudsburg and the Pocono area. Highway commercial uses are developing radially outside the Stroudsburgs and Port Jervis. The Stroudsburgs contain the largest business district and is the primary shopping area. The villages in Monroe County provide the neighborhood or convenience shopping function.

Most industrial areas are located in the regional centers, but are not limited to these areas. For example, in Orange County, industrial development extends beyond Port Jervis, far up the Neversink Valley. A few local industries are found through Pike County on Route 209, and in Monroe County on the Lackawanna and Western Railroad in Stroud Township and Barrett Township. Others are located along Routes 611 and 115. Local centers such as Matamoras Borough, Milford Borough, and Delaware Water Gap Borough have a few industries. The majority of the industries outside the regional and local centers are the extractive type.

Economic base

The economic base of the TIRES area has been examined on a county basis rather than watershed basis as in the water and sewerage investigations. Examination of the economy on such a micro-level as small watersheds would not give a meaningful picture of the present economic base. A better feel for the economy of the region can be obtained by examining the figures on a county basis which include the total effects from smaller areas; significant increases or decreases over a period of time can be more readily determined. The counties that were examined were Sussex and Warren in New Jersey, and Pike and Monroe Counties in Pennsylvania. Orange County, New York, was omitted because such a small portion of that County is included in the TIRES area; county economic figures would give the impression of much more economic activity in the study area than really existed. Furthermore, the small portion of Orange County that is in the study area is not representative of the general economic characteristics of that County. Northampton County, Pennsylvania, was excluded for the same reasons.

Among the economic characteristics examined were the number of employees, payrolls, and total reporting units (as defined below). The years 1959 and 1965 were compared for each county to give a general picture of the increases or decreases in each classification of industry. The information was obtained from County Business Patterns, Bureau of the Census, U. S. Department of Commerce.

The employment figures were based on the number of employees for the pay period ending nearest March 15th, either as reported or as corrected in those cases where reporting was incomplete or inaccurate. The taxable payroll is the amount of taxable wages paid for covered employment during the January - March quarter.

New Jersey counties.--Table C-3 shows that the totals for the number of employees, taxable payrolls, and total reporting units increased from 1959 to 1965 for Warren and Sussex Counties. Although the increase in number of employees, taxable payrolls, and total reporting units is greater for Warren County, the percentage increase for industry in general is larger for Sussex County.

Table C-4 shows that industrial growth between 1959 and 1965 is similar for the United States and New Jersey. The rate of total industrial growth during this period is much higher for Sussex County than for either New Jersey or the whole country.

In Warren County, there has been an increase in the number of employees and the taxable payrolls in almost all industries. One major exception is wholesale trade, wherein decreases of 24 percent in the number of employees and 18 percent in taxable payrolls were recorded. The change in total units reporting between the two years has been mixed with a 23 percent decrease in agricultural services, 40 percent decrease in mining, a 10 percent decrease in contract construction, and a 13 percent decrease in wholesale trade; all other industrial classifications showed an increase in the number of reporting units. Relative growth for the total of all industries in Warren County closely approximates the changes for New Jersey and the United States.

Thus, except for the wholesale trade industry, the economy of Warren and Sussex Counties has been growing at a healthy rate. Employment, taxable payrolls, and the number of reporting units have all generally increased over the six-year period.

Pennsylvania counties.--Pike and Monroe Counties in Pennsylvania, as Table C-5 shows, experienced a similar total employment growth rate between 1959 and 1965. Both are substantially higher than the United States total for the same period. Although a few small employment categories in Pike County showed decreases, the interesting point

TABLE C-3

PAYROLLS, EMPLOYMENT & ESTABLISHMENTS
WARREN & SUSSEX COUNTIES 1959 & 1965

WARREN	Number of Employees Mid-March	1959 Taxable Payrolls Jan.-March	Total Reporting Units	Number of Employees Mid-March	1965 Taxable Payrolls Jan.-March	Total Reporting Units
Agricultural Services, Forestry, Fisheries	22	11	9	39 (77) ²	39 (254) ²	7 (-23) ²
Mining	142	197	5	D	D	3 (-40)
Contract Construction	568	548	144	669 (17)	944 (72)	131 (-10)
Manufacturing	10,148	12,302	117	11,105 (09)	15,496 (25)	122 (04)
Transportation & Pub. Utilities	642	710	52	917 (42)	1,334 (87)	65 (25)
Wholesale Trade	691	808	64	53 (-24)	668 (-18)	56 (-13)
Retail Trade	1,974	1,451	426	2,776 (40)	2,299 (58)	444 (04)
Finance, Insurance, Real Estate	336	254	89	391 (16)	376 (48)	91 (02)
Services	1,211	758	228	1,661 (37)	1,364 (79)	263 (15)
Unclassified	33	19	12	D	D	12 (0)
Total	15,767	17,058	1,146	18,114 (14)	22,543 (32)	1,185 (03)

¹Payrolls in thousands of dollars.

²Number in parentheses indicates percent increase or decrease between 1959 and 1965.

D - denotes figures withheld to avoid disclosure of operations of individual reporting units.
Source: County Business Patterns, 1959, 1965, U.S. Department of Commerce.

TABLE C-3
(continued)

SUSSEX	1959 Number of Employees Mid-March	1959 Taxable Payrolls Jan.-March	Total Reporting Units	1965 Number of Employees Mid-March	1965 Taxable Payrolls Jan.-March	Total Reporting Units
Agricultural Services, Forestry, Fisheries	39	25	11	44 (12) ²	38 (52) ²	15 (36) ²
Mining	227	268	12	396 (74)	527 (96)	8 (-44)
Contract Construction	504	496	130	577 (14)	693 (39)	180 (38)
Manufacturing	2,514	2,472	67	2,903 (15)	3,691 (49)	78 (16)
Transportation & Pub. Utilities	535	461	49	733 (37)	912 (97)	77 (57)
Wholesale Trade	236	238	33	199 (-84)	251 (05)	40 (21)
Retail Trade	1,454	1,109	334	2,051 (41)	1,780 (60)	399 (19)
Finance, Insurance, Real Estate	600	586	50	831 (38)	968 (65)	69 (38)
Services	873	540	155	1,402 (60)	1,143 (111)	225 (45)
Unclassified	88	97	9	38 (-57)	31 (-69)	17 (88)
Total	7,070	6,292	850	9,174 (29)	10,034 (59)	1,108 (30)

¹Payrolls in thousands of dollars.

²Number in parentheses indicates percent increase or decrease between 1959 and 1965.

D - denotes figures withheld to avoid disclosure of operations of individual reporting units.

Source: County Business Patterns, 1959, 1965, U.S. Department of Commerce.

TABLE C-4

PAYROLLS, EMPLOYMENT AND ESTABLISHMENTS

UNITED STATES, NEW JERSEY AND PENNSYLVANIA 1959 AND 1965

	Number of Employees Mid-March	1959 Taxable Payrolls Jan.-March ¹	Total Reporting Units	Number of Employees Mid-March	1965 Taxable Payrolls Jan.-March ¹	Total Reporting Units
UNITED STATES						
Agricultural Services, Forestry, Fisheries	110,388	79,659	23,441	152,420(38) ²	126,463(58) ²	29,285(24) ²
Mining	705,242	920,071	31,801	599,328(-84)	943,743(02)	29,114(91)
Contract Construction	2,498,457	2,823,519	301,604	2,823,519(13)	4,091,886(44)	319,250(06)
Manufacturing	16,206,932	19,671,581	290,902	17,595,093(08)	26,005,596(32)	298,930(02)
Transportation and Public Utilities	2,920,063	3,562,335	120,169	3,218,709(10)	4,869,224(36)	128,659(07)
Wholesale Trade	3,092,243	3,864,865	280,984	3,434,925(11)	5,262,275(36)	303,510(08)
Retail Trade	7,743,908	5,711,112	1,074,215	8,963,742(15)	7,855,798(37)	1,083,206(01)
Finance, Insurance, Real Estate	2,505,432	2,632,730	292,478	3,014,243(20)	3,821,574(45)	325,243(11)
Services	5,795,905	4,561,573	814,730	7,709,154(33)	7,373,155(61)	935,797(14)
Unclassified	274,939	212,154	59,228	231,709(-16)	185,357(-13)	68,605(15)
Total	41,903,940	44,079,557	3,302,563	47,743,277(13)	60,535,046(37)	3,521,554(06)

¹Payrolls in thousands of dollars.²Number in parentheses indicates percent increase or decrease between 1959 to 1965.

SOURCE: County Business Patterns 1959, 1965.

TABLE C-4
(continued)

NEW JERSEY	Number of Employees Mid-March	1959 Taxable Payrolls Jan.-March ¹	Total Reporting Units	Number of Employees Mid-March	1965 Taxable Payrolls Jan.-March ¹	Total Reporting Units
Agricultural Services, Forestry, Fisheries	2,648	2,026	796	3,470(31) ²	3,062(51) ²	904(13) ²
Mining	3,303	4,326	139	3,537(07)	5,314(22)	147(05)
Contract Construction	79,848	100,733	12,742	94,445(18)	148,880(47)	12,918(01)
Manufacturing	782,080	988,443	13,767	813,852(04)	259,383(27)	14,036(01)
Transportation and Public Utilities	115,178	142,765	4,257	131,308(14)	202,324(41)	4,701(10)
Wholesale Trade	100,257	134,743	8,354	125,878(25)	205,714(52)	9,767(16)
Retail Trade	245,583	198,127	37,788	310,271(26)	288,224(45)	38,021(0.6)
Finance, Insurance, Real Estate	83,990	91,892	10,502	98,977(17)	126,899(38)	11,337(07)
Services	190,225	157,152	27,176	256,943(35)	248,312(58)	32,700(20)
Unclassified	7,110	6,230	1,574	7,552(06)	8,106(30)	2,106(33)
Total	1,610,372	1,826,596	117,148	1,846,235(14)	2,496,218(36)	126,729(08)

¹ Payrolls in Thousands of dollars.

² Number in parentheses indicates percent increase or decrease between 1959 to 1965.
SOURCE: County Business Patterns 1959, 1965.

TABLE C-4
(continued)

PENNSYLVANIA	1959		1965		Total Reporting Units
	Number of Employees Mid-March	Taxable Payrolls Jan.-March	Number of Employees Mid-March	Taxable Payrolls Jan.-March	
Agricultural Services, Forestry, Fisheries	3,822	2,535	5,880 (53) ²	5,263 (107) ²	1,077 (20) ²
Mining	67,909	83,881	45,072 (-44)	68,170 (-19)	2,185 (-23)
Contract Construction	143,034	164,367	142,784 (-01)	204,532 (24)	17,945 (-04)
Manufacturing	1,393,359	1,643,999	1,462,294 (04)	2,098,175 (27)	18,518 (01)
Transportation and Public Utilities	191,393	234,184	192,523 (03)	292,340 (24)	7,825 (01)
Wholesale Trade	198,194	257,382	194,476 (-02)	291,417 (13)	16,651 (01)
Retail Trade	492,358	353,944	520,685 (05)	432,117 (22)	62,890 (-05)
Finance, Insurance, Real Estate	144,455	150,590	160,610 (11)	197,075 (30)	14,509 (02)
Services	390,686	284,337	474,453 (21)	416,827 (46)	52,492 (06)
Unclassified	15,170	13,593	10,794 (-29)	8,929 (-35)	2,949 (-02)
Total	3,025,785	3,194,123	3,214,571 (06)	4,014,795 (25)	197,039 (-10)

¹ Payrolls in Thousands of dollars.

² Number in parentheses indicates percent increase or decrease between 1959 to 1965.

TABLE C-5
(continued)

MONROE	1959			1965		
	Number of Employees Mid-March	Taxable Payrolls Jan.-March ¹	Total Reporting Units	Number of Employees Mid-March	Taxable Payrolls Jan.-March ¹	Total Reporting Units
Agricultural Services, Forestry, Fisheries	14	12	3	86 (514) ²	70 (483) ²	11 (266) ²
Mining	16	16	3	25 (56)	28 (75)	3 (0)
Contract Construction	547	394	134	705 (28)	815 (106)	158 (17)
Manufacturing	3,550	3,223	86	4,466 (41)	5,093 (58)	89 (03)
Transportation and Public Utilities	401	412	44	331 (-18)	439 (10)	38 (-14)
Wholesale Trade	439	479	44	300 (-32)	366 (-34)	40 (-10)
Retail Trade	1,588	964	311	2,010 (26)	1,493 (54)	319 (02)
Finance, Insurance, Real Estate	225	172	47	297 (32)	272 (58)	58 (23)
Services	1,960	1,263	253	2,653 (35)	2,108 (66)	310 (22)
Unclassified	50	37	9	16 (-312)	5 (-740)	6 (-44)
Total	8,790	6,972	934	10,889 (23)	10,689 (53)	1,032 (10)

¹Payrolls in thousands of dollars.

²Number in parentheses indicates percent increase or decrease between 1959 to 1965.

D - denotes figures withheld to avoid disclosure of operations of individual reporting units.
Source: County Business Patterns, 1959, 1965.

was the substantial increases in the number of employees and payrolls between the two years in manufacturing, contract construction, and services.

To offset the steady industrial growth in Monroe County, there was a 32 percent decrease in the number of employees in the wholesale trade and a 34 percent decrease in its taxable payroll. Although the percentage of employees, taxable payroll, and total reporting units in "unclassified industries" has decreased, this is not necessarily significant because these industries may have been classified in 1965 as one of the standard industry groups (i.e. agricultural services, mining, manufacturing, etc.)

Employment.--Although the figures for employment are for only the March 15th payroll period, they indicate the basic pattern of distribution of employment by industry. Table C-6 shows the annual number of persons employed covered by state unemployment compensation insurance for the counties. Although Pike and Wayne Counties have the smallest number of people under "covered" employment, they have also undergone the greatest increase in employment between the years 1960 and 1966, with an average of 1,688 additional persons employed each year. Monroe County had an average of 997 additional persons employed each year. Between 1960 and 1966 Warren employed 665 additional persons per year and Sussex County employed 115 additional persons per year.

Unemployment.--Unemployment in the study area has been decreasing at a greater rate than the United States' general rate. As Table C-7 shows, only Sussex County had a greater percentage of the labor force unemployed than did the United States in 1965. The figures for Pike County also include Wayne County because the analysis was made there on a Labor Market Area basis. Although the numbers unemployed for the Honesdale - Matamoras area for the years 1960 through 1965 are high, the percentage unemployed may be considered as representative of Pike County.

With the opening of the DWGNRA and the expected growth in such businesses as restaurants, motor vehicle service stations, motels, lodges, and other tourist establishments, the unemployment rate may continue to decline. It must be mentioned, however, that the anticipated increase in the number of recreational and tourist establishments may intensify seasonal fluctuations in the employment and unemployment rates.

Income.--In the four-county area, as Table C-8 shows, there were \$32,872,813 paid in wages and salaries in the first quarter of 1961. In 1965 this increased by \$9,452,393 to \$42,325,206. Sussex County increased the most in wages and salaries paid during this period. Although wages and salaries in Pike County increased by the smallest

TABLE C-6
COUNTY EMPLOYMENT FOR TIRES AREA COUNTIES

COUNTY	NUMBER OF PERSONS EMPLOYED	
	1960	1966
Warren	24,084 ⁽¹⁾	28,000 ⁽²⁾
Sussex	18,511 ⁽¹⁾	19,200 ⁽²⁾
Pike and Wayne	3,169 ⁽¹⁾	13,300 ⁽³⁾
Monroe	15,517 ⁽¹⁾	21,500 ⁽³⁾

Source:

(1) U.S. Census, 1960

(2) N.J. Division of Employment Security

(3) Manpower Dilemma, Economic Development Council of
Northeastern Pennsylvania, April 1967.

TABLE C-7
UNEMPLOYMENT, 1960-1965

AREA	NUMBER AND PERCENT UNEMPLOYED BY SELECTED YEAR					
	1960	1962	1963	1964	1965	1966
(1) Warren County						
percent	5.5	6.2	6.5	4.7	3.5	3.1
number	1,500	1,700	1,800	1,300	1,000	900
(1) Sussex County						
percent	6.7	5.7	5.8	5.3	4.7	4.0
number	1,100	1,000	1,100	1,000	9,000	8,000
(2) Honesdale-Matamoras (Wayne & Pike Counties)						
percent	5.7	6.4	7.2	5.3	3.8	-
number	800	900	1,000	700	500	-
(2) Stroudsburg (Monroe County)						
percent	5.3	4.1	4.0	3.0	2.9	-
number	1,000	800	800	600	600	-
(3) United States						
percent	5.6	-	-	5.2	4.6	4.0
number	3,931,000	-	-	-	3,456,000	-

Source:

- (1) N.J. Division of Employment Security
- (2) Pennsylvania Statistical Abstract, Pennsylvania Department of Internal Affairs, 1967
- (3) Pocket Data Book, U.S.A. 1967, U.S. Bureau of the Census

TABLE C-8
WAGES AND SALARIES OF
COVERED EMPLOYMENT
FOR THE FIRST QUARTER

	1961	1965	1961-65 (increase)
(1) Warren	\$ 17,729,194	\$ 22,291,767	\$ 4,562,573
(1) Sussex	6,690,619	8,759,439	2,068,820
(2) Pike	546,000	924,000	378,000
(2) Monroe	<u>7,907,000</u>	<u>10,350,000</u>	<u>2,443,000</u>
Total	\$ 32,872,813	\$ 42,325,206	\$ 9,452,393

Source:

(1) N.J. Division of Employment Security, 1961 and 1965

(2) Pennsylvania Statistical Abstract, Pennsylvania Department of Internal Affairs, 1962 and 1967

total, they increased at the greatest rate, almost doubling during the four-year period. Table C-9 shows the family income distribution of the population by counties.

Local studies.--A number of studies have been completed on a township, borough, and county level which have sections that deal with the economic conditions of the individual communities. These reports draw upon some of the same basic data shown above in combination with localized 1960 U.S. Census data. They are useful as reference for a better understanding of the recent economic climate of the communities. The reports generally indicate that the communities have a fairly healthy economic base, are encouraged to attract more industry, and have a favorable potential for doing so. Most also recognize the potential impact of the DWGNRA on the economy of their communities and see with cautious hope the influx of tourist dollars as a good trend. A fear of being buried beneath unattractive advertising devices and marginal "tourist traps", together with the loss of the rural character of the communities is often expressed.

Summary.--Although the counties in the TIRES area are presently in a good economic position, there is not a stable, broad economic basis on which to build. Employment is increasing and unemployment decreasing at greater rates than the national trends. The number of manufacturing establishments reporting in the TIRES area has shown a greater percentage increase between 1959 and 1965 than the United States average. The median family income of the TIRES area counties was generally lower than the \$5,660 of the United States average for 1959. Only Sussex County had a higher median family income (\$5,860) than the national average. The number of people employed in the TIRES area counties is generally highest in manufacturing and the retail operations. The lowest number of persons employed in any industrial classification is characteristically in agricultural services. Employment in the tourist and vacation industry is not currently large enough to have an impact on the region's economy.

Existing highway network

The unique location of the study area within the northeast region of the United States and the kinds of activities which compose the area's economic base are significant determinants of the past and present condition of the transportation facilities. Allentown-Bethlehem, Scranton-Wilkes-Barre, Philadelphia and New York City are among the nearby urban centers which contribute portions of their population to the recreation and tourist industry of the TIRES area. Of prime importance to the area is, therefore, the transportation network which permits the flow of traffic from these urban centers. Manufacturing, another important activity in portions of the study area, is also dependent on good transportation.

TABLE C-9

1959 INCOME OF FAMILIES FOR SUSSEX AND WARREN COUNTIES, NEW JERSEY
AND MONROE AND PIKE COUNTIES, PENNSYLVANIA

<u>FAMILY INCOME</u>	<u>SUSSEX COUNTY</u>	<u>WARREN COUNTY</u>	<u>MONROE COUNTY</u>	<u>PIKE COUNTY</u>
All Families	12,774	16,778	10,464	2,654
Under \$1,000	505	585	489	121
1,000 - 1,999	701	900	691	217
2,000 - 2,999	762	1,242	943	302
3,000 - 3,999	1,257	1,932	1,402	402
4,000 - 4,999	1,544	2,490	1,576	327
5,000 - 5,999	1,881	2,427	1,415	378
6,000 - 6,999	1,392	1,980	1,209	243
7,000 - 7,999	1,134	1,621	790	218
8,000 - 8,999	961	1,077	549	160
9,000 - 9,999	603	693	380	73
10,000 -14,999	1,375	1,373	712	175
15,000 -24,999	518	328	243	23
25,000+	141	130	65	15
Median Family Income \$	5,860	\$ 5,511	\$ 5,093	\$ 4,872

SOURCE: U.S. Census, 1960

Highway travel is the prime means of transportation within the region. The existing highways are typically two-lane paved roads. Problems of parking inadequacies and traffic congestion are characteristic of the small communities in the area, together with rural hazards of sight distance, poor drainage, and unstable shoulders. Figure C-1 shows major, local, state, and federal highways which serve the region.

It is more difficult to move within the TIRES area than it is to reach it. Highway and road improvements are necessary that will facilitate the movement of traffic between the various sections of the area as well as provide access roads from metropolitan centers.

The existing highway situation is not static, and must be considered in conjunction with the proposed road improvements and recommended new highways. A subsequent section of this report reviews currently proposed major highway improvements.

Pennsylvania highways.--Almost all of the major highways in the Pennsylvania portion of the TIRES region intersect in or near the Stroudsburg area. During the summer tourist season these highways often become congested with high volumes of traffic. The major highway arterials include U.S. 209 paralleling the Delaware River from East Stroudsburg northeast to Matamoras, U.S. 6 from Milford northwest to Lake Wallenpaupack, and U.S. 611 from Mt. Bethel along the Delaware River to the Stroudsburg area and then northwest to Mount Pocono.

Interstate 80 is a new limited-access arterial from the Northeast Extension of the Pennsylvania Turnpike east to East Stroudsburg, and onward toward New York. Among the main state roads in the area are Route 402 from Marshalls Corner north to U.S. 6 at Lake Wallenpaupack, Route 191 from the Stroudsburg area northwest to the Pocono Mountains, Route 447 from Analomink north to Canadensis and then into the mountains, Route 715 from McMichaels north to Henryville, and Route 314 from Analomink northwest to Pocono Manor. Route 940 is the main access road from the Northeast Extension of the Pennsylvania Turnpike to the lakes area in the Poconos in Monroe County. Route 390 intersects with Route 447 at Canadensis in Barrett Township; then goes northward outside of the TIRES area to Interstate 84.

An extensive network of minor state and local roads tie all the small village centers and resorts to the major state and national highway network.

New Jersey highways.--The highways in the New Jersey portion of the TIRES area are undergoing congestion problems because of seasonal traffic similar to that which has plagued the Pennsylvania side.

Newton, the largest community in the TIRES area in New Jersey, is at the intersection of State Route 94 and U.S. 206. The major traffic arterials in New Jersey are Interstate 80 from the Delaware Water Gap south through Columbia, and U.S. 206 from Newton northwest to Montague. The state highways in the area include Route 94 from Columbia northeast to Newton and Route 23 from Port Jervis, New York, south to Colesville. Among the important secondary roads in the area are Route 521 from Port Jervis south to Blirstown and Route 519 from Newton north to Beemerville. As in Pennsylvania, an extensive network of local and county roads tie in with the state system.

Railroads in the Tocks Island study area

The TIRES area is served by two mainline railroad corridors. Limited passenger service is offered to the southern portion of the region by the Erie-Lackawanna Railroad. This line provides service from New York to Scranton and points west on what was formerly the railroad's mainline. Stops within the region are at Blirstown, New Jersey and East Stroudsburg, Cresco, and Pocono Summit in Pennsylvania. Interstates 80 and 81E roughly parallel the route of the railroad. In the northern part of the study area, the former mainline of the Erie Railroad from New York City to Binghamton, New York and points west to Chicago, follows the Delaware River from Port Jervis to Lackawaxen and then continues west through Narrowsburg and Hancock, New York. No passenger service is offered on this line west of Port Jervis.

In the past both of these railroads provided frequent passenger service from New York to Buffalo with connections to points west. The mainlines of both railroads were constructed to carry high volumes of passenger traffic and still remain major freight routes between New York City and the west. The use of high-speed arterial highways apparently reduced much of the demand for passenger train service that had existed in the study area.

In the southeastern part of the study area, Sussex County has commuter service between Netcong, Dover, and New York, and electrified commuter trains are operated by the Erie-Lackawanna east of Dover through Morris County to Newark and Hoboken, where rapid transit connections to New York City are available. In addition to the rail corridors from New York and the west, an important freight line, the Lehigh and Hudson Railway, connecting Easton with New England by way of Maybrook and Poughkeepsie, New York, passes through the eastern fringe of the study area. This route also connects with the Pennsylvania Railroad-Erie Lackawanna freight line from Stroudsburg to Trenton.

In addition to the main freight routes, several branch lines are operated in the eastern part of the study area. The Erie-Lackawanna Sussex branch, from Netcong to Branchville, formerly provided commuter service to New York City. The New York and Susquehanna Railroad also provides limited freight service in the eastern and the southeastern part of the study area. This line is the last of several lines which operated between New York City and the anthracite coal region of Pennsylvania.



FIGURE C-1
EXISTING LAND USE MAP

LEGEND

- STUDY AREA BOUNDARY
- RESIDENTIAL
 - PERMANENT AND SEASONAL SUBDIVISIONS
- RESORTS
 - HOTELS, MOTELS, LODGES
 - CAMPS
 - RESORT LAND HOLDINGS
- COMMERCIAL
- INDUSTRIAL
- PUBLIC AND QUASI-PUBLIC
 - INSTITUTIONS AND MUNICIPAL
- WATERSHED AREAS
- RECREATIONAL
 - STATE FOREST, GAME LANDS, PARKS
 - HUNTING AND FISHING CLUB HOLDINGS
- RURAL
- AIRPORT

2 1 0 2 4
SCALE IN MILES

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ON-SITE LIQUID WASTE DISPOSAL

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APPENDIX D

ON-SITE LIQUID WASTE DISPOSAL

Soils of the study area.--The soils of the Pennsylvania section of the study area have been formed largely by glacial action; soil depths range from deep to shallow. The soils are generally better drained on sloping ground. Drainage is poor on the flatlands.

There are two types of glacial materials evident in Pennsylvania:

1. glacial till, composed of sand, silt, clay, and rock fragments set down by the melting ice.
2. glacial outwash, composed generally of sorted sands and gravels deposited by the melting waters of the glaciers as these waters flowed from the ice mass.

A third type of soil is also evident which has been formed from residual material of the parent rock. These areas have also been glaciated, but the effects of the ice action are not as significant as the weathering of the parent rock.

The most significant soil association groups in Monroe and Pike Counties, as described briefly by the Soil Conservation Service in open-file data, are as follows:

<u>Name</u>	<u>Brief Description</u>
Westfield - Culvers - <u>Oquaga</u>	Shallow to deep soil on reddish - acid glacial till of medium textures
<u>Oquaga</u> -- Culvers - Morris	Shallow to deep soils in reddish - brown acid glacial till of medium textures
Chenango - <u>Barbour</u> - Basher	Deep soils from alluvial outwash of varying textures
Culvers - <u>Cattaraugus</u> - Morris	Deep soils, well-drained to poorly drained, from till of medium textures
<u>Wurtsboro</u> - <u>Mardin</u> - Swartswood	Deep soils to moderately deep, well-drained to moderately well-drained, from grayish till of medium textures
<u>Lordstown</u> - <u>Manlius</u> - <u>Oquaga</u>	Moderately deep, well-drained soils on gently sloping to steep uplands in thin till mainly of gray colors.

The New Jersey soils have been less affected by glaciation and result more from weathering of the parent rock materials (limestones and shales). The soils are characterized by sandy and gravelly terraces, with evidences of limestone and other rock outcrops. Drainage of the soils is variable, and again depends to a degree on slope.

The most prominent soil groups in the New Jersey area, with brief descriptions, are as follows:

<u>Name</u>	<u>Brief Description</u>
Chatfield and Oquaga rocky loams	Deep to shallow soils, abundant with stones, boulders, and rock outcrops
Marksboro gravelly loam	Upland, deep soils, slightly acid, may be full of stones and boulders
Wassair and Tounsburry loams	Medium to high lime content soils with abundant blocks of rock
Wassair loam	Shallow limestone soils with blocks of rock

Within the Orange County, New York portion of the study area, the Swartswood - Wurtsboro soil association is the most prevalent. It is a strongly acid, stony soil developed from glacial till derived from sandstones. The second largest soil association group is the Otisville, which is acid, well-drained, and stony; it is derived from coarse glacial gravels. The third, and smallest group, is the Basher - Holly Association, also acid but not stony; it is moderately to poorly-drained and is derived from silty or sandy alluvium.

Suitability of land for on-site waste disposal.--In order to investigate and determine the suitability of land within the study area for on-site liquid-waste disposal, available soils data were collected, organized, and analyzed. These data varied in form, detail, and coverage throughout the study area, but were generally in the form of aerial photographs and maps displaying the various soil types and classifications. The source of these data was the Soil Conservation Service of the United States Department of Agriculture.

Detailed soil maps were not available for the entire study area. Certain areas had no coverage at all, while other areas, although not mapped in detail, had been generally evaluated with soil types placed into large soils-association groups.

Although the data were inconsistent in format and areal coverage, it was used in this study because it appeared reliable in whatever form presented, and a generalized soil evaluation could be made. The generalized evaluation was considered adequate for the scope of this

study. Because of the high degree of variation in soil characteristics between any two locations, the final evaluation of a soil's ability to accept on-site liquid waste disposal must be made at the specific site in question.

The SCS has evaluated each of the soils or soil classes relative to their ability to accept on-site liquid-waste disposal. The soils are distributed among three classes: slight problems to be expected, moderate problems to be expected, and severe problems to be expected with on-site disposal. The degree of problem to be expected, whether slight, moderate, or severe, is based on soil permeability rate, depth to bedrock, seasonal highwater table, slope, stoniness, and flooding. The following table, D-1, summarizes the general limits of the various parameters considered.

Each of the more than one hundred soil types was put into one of the three classifications, plotted on maps or on aerial photographs, and measured to ascertain the area in each group. Because the original soils data were presented on a county basis, they were plotted and tabulated on a county basis as well as for the study area as a whole. Table D-2 summarizes for each county and for the entire study area the approximate number of square miles and the approximate percent of the area of each county wherein slight, moderate and severe problems might be anticipated with on-site, liquid-waste disposal.

In reviewing the data in the table, it is quite obvious that there are large areas which cannot handle high population densities with on-site liquid-waste disposal. Since these studies show that approximately eighty percent of the study area will encounter potentially severe problems with septic tank-type systems, the concern for future sewage problems in the area is validated.

In the preparation of the master plan for sewerage facilities that follows, the above critical areas were closely scrutinized and considered. Unless areas were expected to be kept as open space or in low density development, every attempt was made to incorporate them into a community or regional system for collection and treatment of sewage.

As is discussed in the report, a basic assumption was made that areas with potential future population densities greater than two to three persons per acre should be incorporated in a sewerage system. Historically, sewerage systems have been economically feasible at greater densities. For those areas where it was not economically feasible to provide sewerage, large-lot zoning or other controls (e.g., State Health Department regulations) should be employed to keep population densities below these limits. For areas of low population densities, tile fields can be constructed sufficiently large to function properly since sewage flows from such areas are not normally great enough to seriously threaten ground or surface water with contamination.

TABLE D-1

SOIL LIMITATIONS FOR ON-SITE LIQUID-WASTE DISPOSAL SYSTEMS

Limiting Factors	Degree of Limitation		
	None to Slight	Moderate	Severe
Soil permeability rate	More than 1"/hr. ¹	0.63 to 1"/hr.	Less than .63"/hr.
Depth to bedrock ²	More than 5'	3' to 5'	Less than 3'
Seasonal high-water table	More than 4' below surface	1-1/2' to 4' below surface	Less than 1-1/2' below surface
Slope	0-8 percent	8-15 percent	15+ percent ³
Stoniness	Stony	Very stony	Extremely stony to stony land
Flooding	None	Seldom	Occasional to frequent

¹Possible pollution hazard to surface water and ground water supplies where permeability rates are rapid.

²Crevice, shattered, or dissolved passageways in limestone bedrock may not adequately filter effluent and present a pollution problem.

³Slopes greater than 15 percent have severe limitations because unfiltered effluent may surface on the downhill slope.

TABLE D-2
LIMITATIONS OF SOILS
FOR ON-SITE SEWAGE DISPOSAL IN STUDY AREA

<u>Civil Division</u>	<u>Area, sq.miles</u>	<u>Limitation</u>	<u>Percent of total area</u>
Monroe County	0	Slight	0
	67.2	Moderate	18.4
	296.3	Severe	81.6
Pike County	24.1	Slight	8.8
	12.4	Moderate	4.5
	236.6	Severe	86.7
Sussex County ¹	19.1	Slight	8.4
	54.3	Moderate	23.9
	153.9	Severe	67.7
Warren County	5.7	Slight	6.8
	11.4	Moderate	14.4
	67.9	Severe	79.8
Orange County	(Soils data not available in comparable form)		
TIRES Area	60.4	Slight	6.0
	52.2	Moderate	15.1
	795.3	Severe	78.9

¹ Based on partial data

LIST OF FIGURES

Figure No.	Title
E-1	Existing Major Public Systems

E-1

APPENDIX E

EXISTING WATER, SEWERAGE AND SOLID WASTE DISPOSAL SYSTEMS

Prior to the formulation of alternative water and waste-disposal systems to serve the future population of the TIRES area, complete inventories of existing systems were compiled. The data for the inventories was obtained primarily from the respective State Health Department records. Major facilities, which could be expanded to serve future needs, were field inspected; however, as will be pointed out subsequently, these were few in number. The complete results of the inventories for water and sewerage systems are available as open file data; they are shown graphically on Figure E-1.

Within the TIRES area, there are 32 water systems (public and private) serving a peak summer population of approximately 66,000. Twenty-six of the 32 rely on ground water from springs or wells for supply, three utilize surface water, and the remaining three utilize a combination of surface and ground water sources.

The majority of the water systems are exceptionally small with delivery capacities less than 200,000 gallons per day. These systems were not considered in this present study except to note that distribution facilities did exist. Delivery capacities of this low order of magnitude correspond to service populations of 1,000 to 1,500 and, therefore, would have little impact on supplying future populations.

Further, it was found that the very small systems did not have a high degree of reliability. In most cases, facilities were very old and barely functioning. The facilities had been installed with little or no engineering analysis and design, and were planned by "rules of thumb" criteria.

There are, however, three systems which have a potential for modification, expansion, and inclusion in the water supply plans formulated herein: the East Stroudsburg, Stroudsburg, and Newton systems. The East Stroudsburg treatment facilities are new and include aeration, flocculation, coagulation, filtration, and chlorination; the capacity of the treatment plant is 2.0 million gallons a day (mgd). The Stroudsburg and Newton facilities serve significant populations (12,500 and 7,700 in the summer, respectively), but would require extensive renovation and modification prior to inclusion in any type of regional system.

There are 28 sewage treatment facilities in the TIRES area as shown on Figure E-1. Municipal systems presently serve East Stroudsburg, Stroudsburg, Newton, and Port Jervis with total primary and secondary treatment capacities of 7.7 mgd. In each of the four plants, secondary treatment is provided by trickling filters. Although no data were collected on BOD

removals, it was assumed that 80% removal could be accomplished by each of the four plants.

In addition to the four municipal systems, there are 19 private systems serving resorts, camps, clubs, and schools. These facilities are primarily package plants with small capacities (less than 100,000 gpd) and, in most cases, are not providing adequate treatment.

At the time the inventory was taken, there were five private industrial waste treatment facilities in the TIRES area.

In this study, small private sewage or industrial waste treatment facilities were not analyzed in detail (as with the small water systems) except to note that collection and treatment facilities existed. As is demonstrated in the report, future growth in the TIRES area will require treatment capacities of up to 90 mgd; based upon this magnitude and the contribution existing small systems might make to the total treatment requirement, it did not appear advisable to spend time trying to incorporate them into the various sewerage system alternatives. Also, because a basic premise of a high degree of treatment (including tertiary treatment for effluent polishing and nutrient removal) was assumed herein, it is very doubtful that any of the small facilities are capable of producing treated effluents of comparable high quality.

The four large municipal systems, however, were studied more closely because they have significant treatment capacity, are not very old, and are presently providing acceptable secondary treatment. It was assumed that these plants could operate until their design capacities were met with the addition of tertiary treatment facilities for effluent polishing and nutrient removal.

The East Stroudsburg plant has a capacity of 1 mgd and provides primary and secondary clarification and two-stage trickling filtration. It contains a comminutor, chlorine feed facilities and contact tank, sludge digestion, and sludge drying beds. The effluent discharges to the Brodhead Creek. The Stroudsburg plant also has a design capacity of 1 mgd, employs the same processes and facilities as the East Stroudsburg plant and also discharges its effluent to the Brodhead. The Stroudsburg plant is about 15 years old and the East Stroudsburg facility is only about 5 years old.

The Newton plant is designed for 0.7 mgd and discharges to Moore's Brook; the brook eventually carries the effluent to the Paulins Kill. The Port Jervis treatment facility is owned and operated by the New York City Department of Water Supply, Gas and Electricity under a court ruling as compensation for upstream diversionary rights; it has a design capacity of 5 mgd. Both of these facilities employ the same unit treatment processes employed in the East Stroudsburg and Stroudsburg plants.

Solid waste disposal in the TIRES area is handled almost exclusively by open dumps and sanitary landfills. The one exception is a teepee type incinerator serving the Borough of Newton.

A survey of the study area indicated a general lack of regulation and control of on-premise refuse storage and refuse collection. Evidence of the inadequacy of refuse storage in developed and undeveloped areas can be seen by the frequency of storage of refuse in 55-gallon drums, the burning of refuse, and the promiscuous dumping on vacant lots. These poor environmental health practices contribute to mounting problems of air pollution, nuisance, and community health.

Through a survey of the study area it was determined that there is a combination of municipal and contracted garbage and rubbish collection. In some areas the municipal service is limited to the collection of garbage only and the rubbish is privately contracted.

Collection is provided by the municipality or by contract in the following:

<u>New Jersey</u>	<u>New York</u>	<u>Pennsylvania</u>
Newton	Port Jervis	Matamoras Boro. Mt. Pocono Boro. Milford Boro. Barrett Twp. East Stroudsburg Boro. Delaware Water Gap Boro.

In the rest of the study area individual residential dwellings, commercial, or industrial enterprises must seek their own private collector or transport their garbage to a disposal area.

In the past, collection service has tended to follow a pattern. As a rural community becomes urbanized, disposal of garbage and refuse by the individual householder proved difficult. A municipal garbage collection service was instituted and eventually extended to collect other refuse when the community became more densely populated. Under conditions of accelerated growth, however, the need for a complete collection and disposal service is immediate in practically all instances.

Seasonal residential dwelling units and weekend residents have special refuse collection problems. One current practice is to carry the garbage back to the permanent dwelling in the urbanized area where it is collected, but all too often the garbage is deposited along the road or in a state roadside rest area. Some of the larger seasonal developments, through community organizations, have contract collection.

Figure E-1 shows the general location of public dumps, private dumps, public sanitary landfills, and private sanitary landfills.

The classification of a site as a dump or a landfill was done by subjective observation during January 1968; this report recognizes that a temporary poor practice may be corrected.

The Township of Sparta, Sussex County, New Jersey, acquired during 1967 a sanitary landfill site capable of serving virtually all of the surrounding area. This site can provide a long-term solution to the problem.

The cooperative East Stroudsburg Borough, Stroudsburg Borough, and Stroud Township sanitary landfill site for the disposal of refuse and garbage was established in 1961. The 20 acre landfill site is located south of the Interstate 80 bridge over the Brodhead Creek in East Stroudsburg. The facility is operated jointly by the three communities through a Board comprised of 3 members; one for each community. Each community contributes funds to this Board in proportion to their respective populations.

Cover material at the East Stroudsburg Sanitary Landfill site has been expended, thereby making it necessary to relocate the landfill. In addition, a leachate problem has developed. The Board has gone through the process of trying to find another location that is acceptable to the Pennsylvania Department of Health. Preliminary investigation of the "Brislin site" which is located on the western edge of Stroud Township indicates that the site is very suitable, but has a potential useful life of only about seven years.

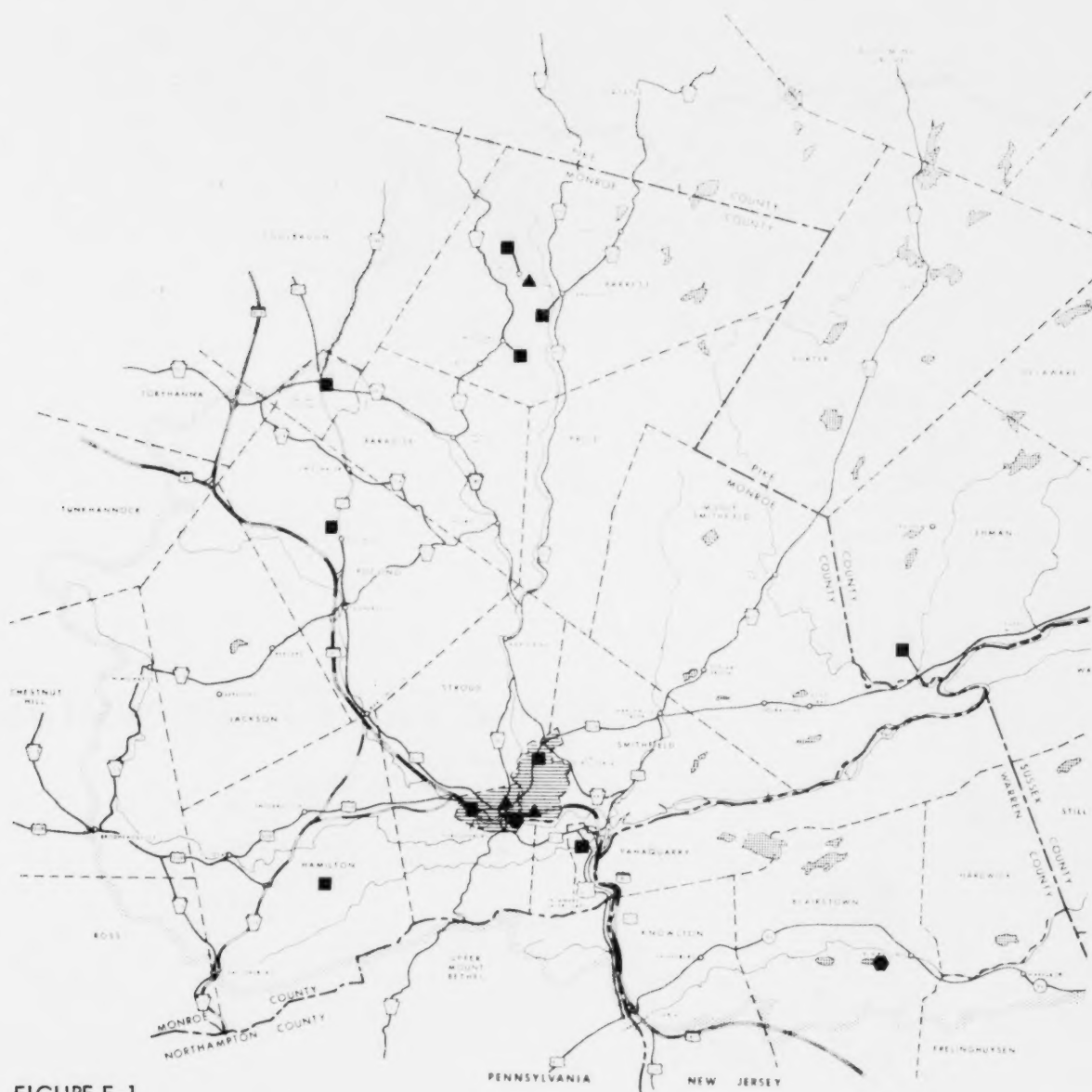


FIGURE E-1
DELAWARE RIVER BASIN COMMISSION

THIS PROJECT WAS SUPPORTED IN PART BY A
DEMONSTRATION GRANT, NUMBER WPD-136,
FROM THE RESEARCH AND TRAINING GRANT
PROGRAM, FEDERAL WATER POLLUTION CONTROL
ADMINISTRATION.

E-5

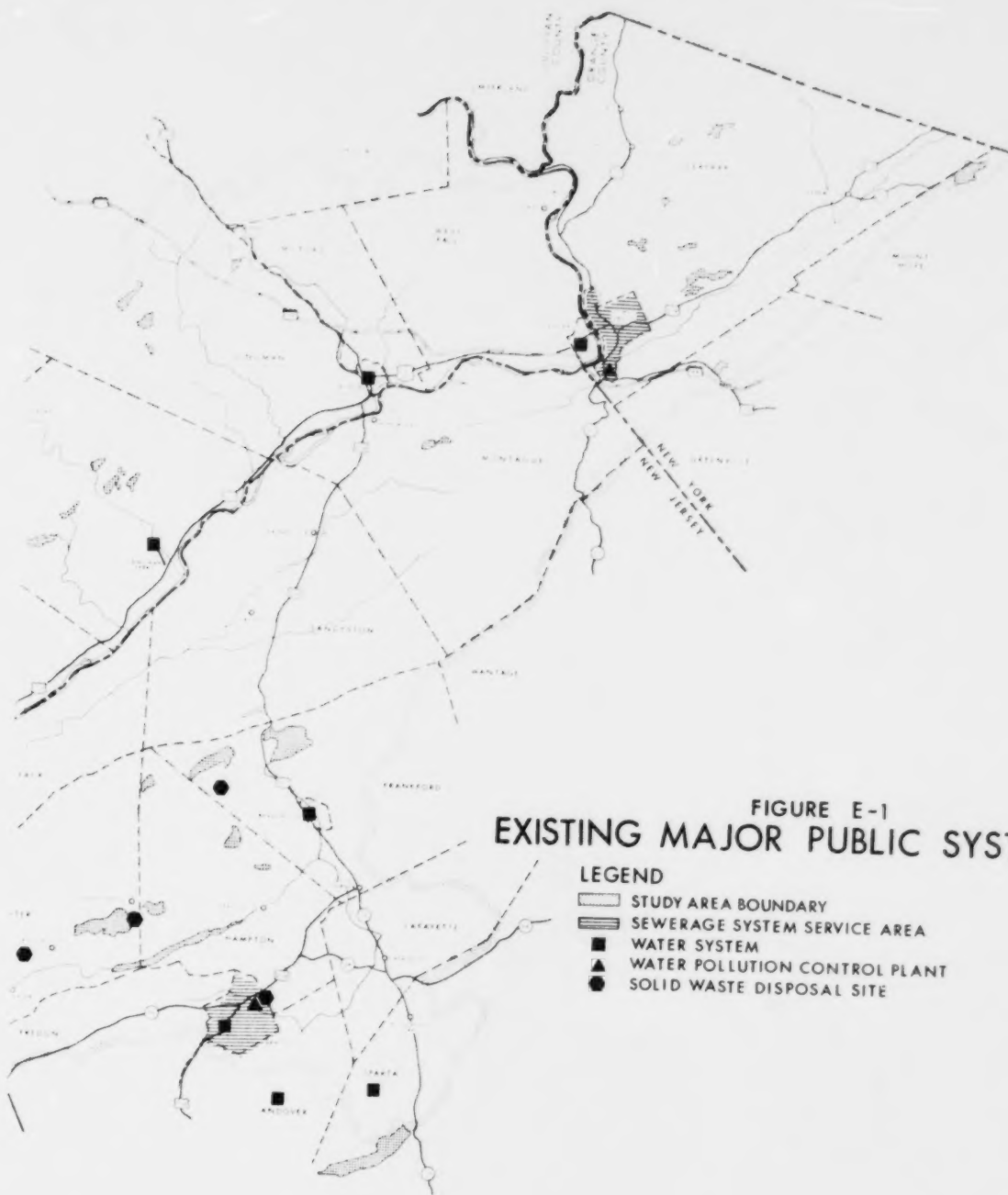


FIGURE E-1
EXISTING MAJOR PUBLIC SYSTEMS

- LEGEND
- STUDY AREA BOUNDARY
 - SEWERAGE SYSTEM SERVICE AREA
 - WATER SYSTEM
 - WATER POLLUTION CONTROL PLANT
 - SOLID WASTE DISPOSAL SITE

2 1 0 2 4
SCALE IN MILES

E-6

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Future Land Use

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APPENDIX F

FUTURE POPULATION, ECONOMIC BASE, TRANSPORTATION, AND LAND USE CONDITIONS

POPULATION FORECASTS

Prior studies

The two major prior studies concerning population forecasts for the TIRES area are "Potential Impact of the Delaware Water Gap National Recreation Area" by Robert R. Nathan Associates (1965) and "A Sketch Plan for the Tocks Island Region", completed November, 1966, by Raymond and May Associates (1966). In addition there are several local, county, and state planning reports and file data which contain population estimates for Minor Civil Divisions within the TIRES area. Most of these reports deal only with estimates of the permanent, year-round population and make no mention of summer residents and visitors.

Nathan Associates' estimates.--The Nathan Associates have made 1985 population estimates for the Pennsylvania and New Jersey counties in the study area. Their study focuses on metropolitan spread and improved highway access as the two most significant elements in the population growth of the TIRES area. The conclusions of their population study and projections are given in Table F-1. A wide range of estimates are given reflecting various inputs. Column II shows 1975 projections made by Temple University and are included in the Nathan report. Column III provides two estimates of the number of housing units which would be built between 1960 and 1975. They are based on two assumptions; the lower estimate is derived by applying the 1960 occupancy rates to the projected population growth. The higher figures were obtained by assuming the average annual level of dwelling unit construction between 1950 and 1960 would be maintained throughout the 1960 - 1975 period. The higher figure includes estimates of construction of vacation as well as year-round homes.

The estimated 1985 population given in Column IV is based on recorded lots in active subdivision. It assumes that two-thirds of these lots will have houses built on them between 1960 and 1985. The middle and high estimates consider what may happen if more land is brought under subdivision, or if the ratio of two lots per house is reduced. Column V is the number of new houses that are estimated to be constructed between 1960 and 1985 based on the 1950 - 1960 rate.

Column VI is the difference between Column V and Column III. It assumes a possible phasing of housing construction over the next 25 year period.

The Nathan Associates' estimates, due to the scope of their study, are largely based on historical trends, and are not designed to accurately assess the impact of DWGNRA on the surrounding communities and counties. Although subdivision and building rates were included in the estimates, the subdivision activity in the area has been extensive

TABLE F-1

GROSS ESTIMATES OF POPULATION GROWTH
AND HOUSING CONSTRUCTION IN THE FOUR
COUNTIES MOST AFFECTED BY DWGNRA
DEVELOPMENT, 1960-1975 AND 1975-1985

County	1960 Population	Projected 1975 Population ¹	Estimated Housing Construction (No. of Units)
	I	II	III
<u>Pennsylvania</u>			
Pike	9,200	11,100-13,500	650 1,400
Monroe	39,600	50,900-60,400	3,400 8,200
<u>New Jersey</u>			
Warren	63,200	78,200-80,900	4,500-5,400 6,300
Sussex	49,200	72,000-73,700	6,700-7,200 11,500
Four-County Total	161,200	212,200 228,500	15,250 16,800 27,400

¹Sources for Column II: For Pike and Monroe Counties, Pennsylvania State Planning Board, *The Population of Pennsylvania*, June 1, 1963; and for Warren and Sussex Counties, State of New Jersey, Division of State and Regional Planning, *Population Projections for New Jersey Counties*.
²Source: Division of State and Regional Planning Projection, Op. Cit.
³Source: The 1985 Sussex County projections are from Alvin E. Gersten Associates, *Sussex County New Jersey, Master Plan Series Report No. 3*, May 1969.
 The highest range estimates and the dwelling unit construction figures derived from them (see text) represent an outside maximum based on assumptions not entirely relevant to this study. They are presented for illustrative purposes only and distinguished by parentheses.
⁴Computed difference between Column V and the higher range estimates in Column III.

Note: Unless so designated above, all other estimates are derived by Robert R. Nathan Associates, Inc., on the basis of assumptions discussed in the text.

Estimated
1985
Population

IV

16,400
18,000
27,000

63,000
75,000
85,000

90,000²
126,000
158,000

133,000³
287,000³
(751,000)³

302,400
506,000
(1,021,000)

Total Estimated
Housing Construction
1960-1985

V

5,000
7,800
14,300

13,700
21,500
24,000

16,000
20,000
30,000

15,000
60,000
(196,000)

49,700
109,300
(364,300)

Estimated Housing
Construction
1975-1985⁴

VI

3,600
6,400
12,900

5,500
13,300
15,800

9,700
13,700
23,700

3,500
48,500
(184,500)

18,900
78,500
(233,500)

since the estimates were prepared. Therefore, some of their assumptions, such as 50 percent of new construction will be for vacation use in 1985, will require testing and analysis if and when proper data is obtained. Little mention was made of the unique characteristics or attractions of each county and their consequent effect on the economic development of the county.

Raymond and May estimates.--The Raymond and May (1966) Sketch Plan is predominately concerned with potential physical development in the TIRES area. No complete study of future population was made although some generalized estimates were ventured. The report indicates that the region's year-round population is expected to increase over four times during the next 35 years.

There were no estimates made of the summer population in the two New Jersey counties. (The portion of Orange County, New York, that is within the TIRES area was not included in the scope of the Raymond and May Sketch Plan). As the report states, these population projections should be considered only as very broad estimates.

Pennsylvania Department of Highways' estimates.--The Advanced Planning Division of the Pennsylvania Department of Highways has made population projections for the year 1990 for the MCD's in Pennsylvania and New Jersey that are within the TIRES area. The figures (unofficial file data) are based on ratio-extrapolation methods and were used to evaluate possible highway needs for the study area. Population projections for the various MCD's within the counties located in the TIRES area are given in the following tables (Nos. F-2 to F-5).

Pennsylvania State Planning Board estimates.--Annually, the Pennsylvania State Planning Board estimates population by county and city. Although these figures do not include the New Jersey counties, they do present a useful picture of estimated current population of the two Pennsylvania counties in the TIRES area. The current report states:

"These estimates are based on birth and death statistics maintained by the Pennsylvania Department of Health and an estimate of the total population of the State made by the U. S. Bureau of the Census. The method employed assumes that changes in the number of births and deaths in a sub-area of the State reflect changes (due to births, deaths, and migration) in the population of that sub-area. Given the current vital statistics and an estimate for the total population of the State, it is possible to calculate each sub-area's share of the State total. Because a three-year moving average is used, final estimates for a given year are available after termination of the following year. Thus, in 1967, final estimates are made for 1966 by producing the trend observed between the last census (1960) and the final estimate for 1965."

TABLE F-2

PENNSYLVANIA DEPARTMENT OF HIGHWAYS
POPULATION PROJECTIONS FOR
SUSSEX COUNTY, NEW JERSEY

<u>Minor Civil Division(s)</u>	<u>1990 Population (Summer)</u>	<u>1990 Visitors (per year)</u>
Byram	78,750	118,200
Sparta	90,860	136,350
Hardyston	84,310	126,000
Vernon	24,770	37,200
Wantage	57,290	85,950
Sandyston	21,910	33,000
Frankford	36,170	54,150
Lafayette	12,700	18,900
Hampton	13,570	19,650
Stillwater	18,320	27,300
Fredon	9,280	13,950
Green	9,860	15,700
Andover	<u>89,900</u>	<u>134,700</u>
Total	<u>547,690</u>	<u>821,050</u>

- Notes: 1. Approximately 40 percent of total population are summer residents.
2. Byram Township includes Hopatcong and Stanhope Boroughs.
3. Sparta Township includes Ogdenburg Boroughs.
4. Hardyston Township includes Franklin Township and Hamburg Boro.
5. Wantage Township includes Sussex Boro.
6. Sandyston Township includes Montague Township.
7. Frankford Township includes Branchville Borough.
8. Stillwater Township includes Wallpack Township.
9. Andover Township includes Andover Boro and Newton Boro.

Source: Advanced Planning Division of the Pennsylvania Department of Highways.

TABLE F3

PENNSYLVANIA DEPARTMENT OF HIGHWAYS
POPULATION PROJECTIONS FOR
WARREN COUNTY, NEW JERSEY

<u>Minor Civil Division(s)</u>	<u>1990 Population (Summer)</u>	<u>1990 Visitors (per year)</u>
Independence	18,630	27,900
Allamachy	2,660	3,900
Liberty	7,940	11,850
White	17,840	26,550
Oxford	111,740	95,750
Hope	2,280	3,450
Frelinghuysen	2,320	3,450
Hardwick	1,200	1,830
Blairstown	4,930	7,500
Knowlton	<u>3,960</u>	<u>6,000</u>
Total	<u>173,500</u>	<u>185,480</u>

- Notes: 1. Approximately 10 percent of total population are summer residents.
2. Independence Township includes Hadkettstown Borough.
3. Liberty Township includes Mansfield Township.
4. White Township includes Belvidere Boro and Harmony Township.
5. Hardwick Township includes Pahaquarry Township.
6. Oxford Township includes Washington Township, Washington Boro, Franklin Township, Greenwich Township, Pohatong Township, Alpha Boro, Lopatoncong Township, and Phillipsburg Boro.

Source: Advanced Planning Division of the Pennsylvania Department of Highways.

TABLE F-4

PENNSYLVANIA DEPARTMENT OF HIGHWAYS
POPULATION PROJECTIONS FOR
MONROE COUNTY, PENNSYLVANIA

<u>Minor Civil Division(s)</u>	<u>1990 Population (Summer)</u>	<u>1990 Visitors (per year)</u>
Polk Twp.	3,240	1,600
Eldred Twp.	2,800	1,400
Chestnut Hill Twp.	4,720	7,050
Ross Twp.	2,470	3,750
Tobyhanna Twp.	710	1,050
Coolbaugh Twp.	6,400	9,600
Mount Pocono Boro.	2,185	3,300
Barrett Twp.	7,170	10,800
Paradise Twp.	2,985	4,500
Price Twp.	335	1,200
M. Smithfield Twp.	3,150	4,800
Hamilton Twp.	3,050	4,650
Jackson Twp.	2,675	4,050
Pocono Twp.	1,910	2,850
Stroud Twp.	20,870	31,300
Stroudsburg Area	35,570	53,400
D. Water Gap Boro.	1,450	2,250
Smithfield Twp.	<u>11,265</u>	<u>16,800</u>
Total	<u>116,720</u>	<u>165,950</u>

- Notes: 1. Approximately 33 percent of the total population are summer residents.
2. Stroudsburg Township includes Stroudsburg, Arlington Heights, Pocono Boro. and East Stroudsburg Boroughs.

Source: Advanced Planning Division of the Pennsylvania Department of Highways.

TABLE F-5

PENNSYLVANIA DEPARTMENT OF HIGHWAYS
POPULATION PROJECTIONS FOR
PIKE COUNTY, PENNSYLVANIA

<u>Minor Civil Division(s)</u>	<u>1990 Population (Summer)</u>	<u>1990 Visitors (per year)</u>
Lackawaxen Twp.	4,185	2,100
Palmyra Twp.	2,565	3,750
Blooming Grove Twp.	1,615	2,400
Greene Twp.	3,100	4,650
Shohola Twp.	1,625	2,400
Westfall Twp.	11,415	17,250
Porter Twp.	205	270
Milford Boro.	7,715	11,550
Delaware Twp.	2,125	3,150
Lehman Twp.	<u>1,270</u>	<u>1,950</u>
Total	<u>35,820</u>	<u>49,470</u>

- Notes: 1. Approximately 66 percent of the total population are summer residents.
2. Westfall Township includes Matamoras Borough.
3. Milford Township includes Dingman Township and Milford Boroughs.

Source: Advanced Planning Division of the Pennsylvania Department of Highways.

These figures (see Table F-6) reveal that the populations of the two TIRES counties are growing at a greater rate than the state population. Between 1960 and 1965 the population of Monroe County has increased ten percent and Pike County eight percent, while Pennsylvania increased only 2 percent. Between 1965 and 1966 both Monroe and Pike Counties' population increased two percent, but the State population increased only 0.4 percent. It is important to note that these figures are for permanent residents only.

Orange County Data Book.--This publication shows the results of a 1967 special county population census by the U. S. Bureau of the Census. During the period 1960-1967, the population of the Town of Deerpark increased by 1,021 persons, from 2,777 to 3,798 (+36.8 percent); the City of Port Jervis decreased by 667 persons from 9,268 to 8,601 (-7.2 percent); and Orange County's total population increased from 183,734 persons to 209,141 (+13.8 percent).

Local projections.--Several local comprehensive plans and planning reports, other than those reviewed above, include estimates of future population. Again, these projections do not include second-home owners or tourists.

Table F-7 summarizes the various estimates made in some of the local reports. Since a variety of methods were used, the various projections are probably not comparable with each other.

Forecasts

Introduction.--Because of its proximity to the several metropolitan areas, and because of the magnitude of the proposed recreational facilities, the study area is expected to be a major location of rapid population growth in the northeastern United States.

The population trends in the counties included within the influence of the DWGNRA already begin to show indications of the intense demand expected to develop. Table F-8 shows the gains in seasonal and permanent population that each of the principal counties experienced between 1950 and 1960.

Interestingly, Sussex County, New Jersey, the closest to the urban axis, has experienced an extremely rapid increase in permanent as well as seasonal population. This high rate of increase in permanent population is unusual, since the county has traditionally been a resort and vacation area. There is, however, evidence that the trend toward permanence is intensifying. Although it is not yet clear what the characteristics of the new permanent population will be, there is little doubt that the County is entering a period of intense residential development. This development will have implications not only for the residential character of Sussex County but also for the housing demand which can be expected in the neighboring counties in Pennsylvania. As Sussex County becomes more developed, recreation demand can be expected to spill into Pennsylvania at an increasing rate.

TABLE F-6
MONROE AND PIKE COUNTY AND PENNSYLVANIA POPULATIONS
1960, 1965, 1966

<u>County</u>	<u>1960 Census</u>	<u>July 1, 1965 Final</u>	<u>July 1, 1966 Provisional</u>
Monroe	39,567	43,700	44,600
Percent Increase	-	10	2
Pike	9,158	9,900	10,000
Percent Increase		8	2
Pennsylvania	11,319,366	11,583,000 ¹	11,637,900
Percent Increase		2	.4

¹ Estimate by U. S. Bureau of the Census
Source: Pennsylvania State Planning Board

TABLE F-7

SUMMARY OF PRIOR POPULATION PROJECTIONS FOR TIRES AREA

	1970	1975	1980	1985	1990
MONROE					
E. STROUDSBURG	7200-7500 ^B	50,900-60,400 ^G	7500-8500 ^B	63,000-85,000 ^G	
STROUD TOWNSHIP	8553 ^C		13380 ^C		
BARRETT TOWNSHIP	2935 ^D		3815 ^D		
PIKE		11,100-13,500 ^G		16,400-27,000 ^G	
SUSSEX		72,000-73,700 ^G		133,000-287,000 ^G	
WARREN	72,700-85,000 ^F	78,200-80,900 ^G	87,200-125,000 ^F	90,000-158,000 ^G	134,000-160,000 ^F
ORANGE	235,000 ^E	270,000 ^E	310,000 ^E	400,000 ^C	
DEERPARK		6,000 ^A			

SOURCE:

- A. Raymond and May Associates, Town of Deepark, Development Plan, Part 2, 1967.
- B. Candeub, Cabot, and Associates, Comprehensive Plan for the Borough of East Stroudsburg, 1963.
- C. Candeub, Cabot, and Associates, Land Use Plan for Stroud Township, 1966.
- D. Bellante and Clauss Inc., Comprehensive Plan for Barrett Township, 1962.
- E. The Port of New York Authority, The Next Twenty Years, 1966.
- F. Herbert H. Smith Associates, Warren County Development Plan, 1964.
- G. Robert R. Nathan Associates, Potential Impact of the Delaware Water Gap National Recreation Area on its Surrounding Communities, 1966.

TABLE F-8
SEASONAL AND PERMANENT POPULATION IN
TOCKS ISLAND COUNTIES

<u>County</u>	<u>1950</u>			<u>1960</u>		
	<u>Permanent</u>	<u>Seasonal</u>	<u>Total</u>	<u>Permanent</u>	<u>Seasonal</u>	<u>Total</u>
Sussex	34,423	28,896	63,319	49,255	40,024	89,279
Warren	54,374	5,564	59,938	63,220	5,384	68,604
Pike	8,425	11,108	19,533	9,158	25,148	34,306
Monroe	33,773	16,948	50,721	39,567	24,448	64,015
Orange	152,255	24,604	176,859	183,734	40,688	224,422

Note: Permanent population is the resident population enumerated in April of the censal year.

Seasonal population is estimated at 4 persons per seasonal dwelling unit.

Sources: Permanent population, U.S. Census of Population. Seasonal population, U.S. Census of Housing. Seasonal dwellings are defined in 1950 as the sum of: (1) seasonal units; and (2) nonseasonal, not dilapidated units that are not for rent or sale in 1960; seasonal dwellings are defined as the sum of: (1) seasonal units, (2) units held for occasional use, and (3) units held for other use.

Thus far, the important trends in the Pennsylvania counties are predominantly in seasonal housing. The seasonal housing stock increased 127 percent in Pike County and 48.4 percent in Monroe County from 1950 to 1960 while, at the same time, the increase in permanent population in Pike was 8.7 percent and 17.2 percent in Monroe.

Since 1960 and the introduction of the Tocks Island and DMGNRA projects, every indication points to the intensification of the development rates. Subdivision recordings and assessed valuation have steadily increased in all MCD's.

Although these general growth trends are obvious, the ill-defined nature of the second-home market, and of recreation demand in general, make projection of future population in the Tocks Island area extremely difficult. Previous attempts were noted in an earlier section of this report, and the underlying methodologies were outlined. It was immediately obvious that even the best approach was little more than a rule of thumb estimate owing to the special character of the area.

In an area so complex, there is no justification for the assumptions which underlie traditional projection methods. "Linear" growth assumptions or semi-log techniques, for example, can produce unreasonable conclusions in many cases. As an illustration of this, if Delaware Township were to grow in the future as it did between 1950 and 1960, its population would increase from 2,399 in 1960 to 4,407 in 2020. If the 1960-1966 growth rate were to persist, however, the 2020 population of the Township would be 1,135,051. This drastic difference in growth rates is typical of the nature of the growth processes which are now acting in the study area and is a major reason why traditional techniques were found to be lacking.

Other projection methods, such as the component method using cohort-survival were considered, but quickly dismissed in view of their data requirements and analytic properties. The cohort-survival technique, for example, requires that estimates of future age-sex-specific migration rates be supplied. In the TIRES area, migration rates, not birth and death rates, are the crucial considerations. An independent estimate of these rates required by age and sex, would almost obviate the need for population projections and would be extremely difficult and inaccurate.

Methodology.--The inability of existing population projection techniques to reflect the rapid changes in growth rate that are expected in the TIRES area led to the development of a new projection method. This approach is an attempt to go beyond the simple extension of past trends by introducing a self-correcting, or feedback, mechanism into the population projections.

In the new system, initial assumptions are made and stated precisely; in conjunction with historical data, they are then used to construct a first stage projection. As soon as new information is introduced to the system (e.g. a new population census) the initial

assumptions are re-evaluated, and an improved second stage projection is generated. This process of continual re-evaluation should continue into the future.

The initial assumptions which must be made are denoted as decision variables, and are of two major types. The first type concerns maximum rate of growth and the second, timing of development. The expected growth in each area is classified with respect to magnitude as high, moderate or low and with respect to time as early, average or late. On the basis of these two decision variables and historical data, projections are made, internal consistency checks provided to insure that the growth in each area is related to the growth around it, and a formal feedback mechanism is initiated.

The fundamental tool in the technique is a modification of the logistic curve, a flattened s-shaped curve which is bounded from above and below. This curve has the ability to reflect rapid rates of growth, but it does not have the undesirable property of allowing these rates to continue unchecked indefinitely. Rather, it embodies the reasonable assumption that growth rates will initially increase, reach a peak, and then begin to decline slowly. The logistic curve has been found to reflect, with reasonable precision, the growth of population in other areas.

It should be noted that the final projection method which is presented here was chosen from among four approaches that were developed on the basis of the logistic curve. The other three were rejected because of the large number of necessary assumptions and of their inflexibility to the rapid changes in growth rate which are expected in the TIRES area.

Projections of total peak summer population.--The primary objective of the population projections was to estimate peak summer population in the sub-drainage basins. Therefore, the estimates include the total of permanent population, seasonal population, and transient population.

Although the geographic area of primary interest was the sub-drainage basin, initial projections on the basis of this unit were impossible because of the lack of data. Consequently, projections were made using the minor civil divisions (MCD's) for which published data are more readily available. Once MCD estimates had been obtained, these were assembled to give projections by sub-drainage basin. If an MCD lay within more than one sub-basin, the MCD population was allocated among sub-basins on the basis of the distribution of the MCD's usable land acres (see Appendix B).

The first step in obtaining MCD population projections was to assemble the required historical data in the form of estimates of 1960 and 1966 peak summer populations. These are presented in Tables F-9 and F-10, listed by minor civil division.

TABLE F-9

ADJUSTED HISTORICAL POPULATION DATA:
NEW JERSEY AND NEW YORK MINOR CIVIL DIVISIONS

County	Minor Civil Divisions	Permanent ¹ Population	Peak Summer Population ²	
		1960	1960	1966
ORANGE	Deerpark	2,777	4,299	6,500
	Greenville	890	1,293	1,710
	Mt. Hope	2,291	3,069	3,450
	Port Jervis City	9,268	9,528	9,740
SUSSEX	Andover Twp.	2,177	3,340	3,475
	Branchville Borough	963	1,004	1,190
	Frankford Twp.	2,170	4,751	6,610
	Fredon Twp.	804	1,096	1,755
	Hampton Twp.	1,174	2,242	4,100
	Lafayette Twp.	1,100	1,141	1,610
	Montague Twp.	879	1,399	2,260
	Newton	6,563	6,692	8,000
	Sandyston Twp.	1,019	4,204	5,265
	Sparta Twp.	6,717	10,610	14,450
WARREN	Stillwater Twp.	1,339	9,447	11,675
	Blairstown Twp.	1,797	2,123	3,000
	Frelinghuysen Twp.	845	1,018	1,900
	Hardwick Twp.	370	546	1,200
	Knowlton Twp.	1,442	1,727	2,300
TOTAL		44,585	69,529	90,190

Notes: ¹ U.S. Census, April 1960

² See text for method of estimation by consultant.

TABLE F-10

ADJUSTED HISTORICAL POPULATION DATA:
PENNSYLVANIA MINOR CIVIL DIVISIONS

County	Minor Civil Division	Permanent ¹ Population	Peak Summer Population ²	
		1960	1960	1966
PIKE	Blooming Grove Twp.	424	1,260	1,966
	Delaware Twp.	549	2,336	3,259
	Dingman Twp.	382	1,117	1,592
	Greene Twp.	793	2,409	3,066
	Lehman Twp.	318	2,541	3,394
	Matamoras Borough	2,087	2,223	2,621
	Milford Borough	1,198	1,414	1,700
	Milford Twp.	386	834	910
	Porter Twp.	51	687	774
	Shohola Twp.	413	1,860	2,749
	Westfall Twp.	838	1,476	2,082
MONROE	Barrett Twp.	2,395	5,231	6,255
	Chestnut Hill Twp.	1,572	2,859	4,099
	Coolbaugh Twp.	1,912	2,828	3,745
	Delaware Water Gap Borough	554	589	---
	East Stroudsburg Borough	7,674	7,966	8,770
	Hamilton Twp.	2,405	3,849	4,437
	Jackson Twp.	878	1,978	3,008
	Middle Smithfield Twp.	1,034	3,493	5,683
	Mt. Pocono Borough	935	1,359	1,556
	Paradise Twp.	982	2,406	3,518
	Pocono Twp.	1,474	2,543	3,100
	Price Twp.	258	479	642
	Ross Twp.	803	844	1,295
	Smithfield Twp.	1,887	4,221	5,330
	Stroud Twp.	5,452	7,611	8,927
	Stroudsburg Borough	6,070	6,242	6,700
	Tobyhanna Twp.	1,073	3,270	5,149
	Tunkhannock Twp.	214	439	827
TOTAL		45,016	76,364	97,654

Notes: ¹U.S. Census, April 1960.²See text for method of estimation by consultant.

The 1960 seasonal population figures were estimated for each MCD on the basis of the following procedure:

1. The total number of sound and deteriorating units with plumbing was determined from the U. S. Census of Housing.
2. Available vacant and other vacant units were added to find total vacant units; owner occupied and renter occupied dwellings were added to find total occupied dwellings.
3. Dilapidated housing was distributed proportionately among occupied and vacant housing.
4. Ninety-five percent of occupied housing was assumed to have plumbing.
5. The total number of occupied units with plumbing was determined by taking 95 percent of occupied units and subtracting the estimated dilapidated occupied units.
6. Occupied units with plumbing were subtracted from total units with plumbing, to find vacant units with plumbing.
7. Units with plumbing were distributed proportionately between available vacant and other vacant units.
8. Other vacant housing with plumbing was considered to have an average household size of four persons; other vacant housing without plumbing was considered as having an average household size of one person.

The 1966 estimates for Sussex and Warren Counties were taken from work prepared by the DRBC and are based on building permit records.

In Pike County, the first method used for 1966 estimates was somewhat different. Since building permits were not available, estimates were based on scattered data such as occasional special censuses, electric meters, or the rate of subdivision recording. These disparate sources were inadequate, however, for an estimate for Monroe County. Therefore, a new method was devised for Monroe County and eventually generalized for Pike. The ratio of 1960 total population to assessed valuation was applied to 1966 assessed valuations and the resultant population was found to correspond very closely to other independent estimates supplied by the DRBC. As can be seen from Table F-10, this method provided reasonable estimates; the greater population in Monroe County MCD's can be easily understood in light of the recent subdivision activity noted in that County.

In most cases, no explicit treatment is given to summer camp and resort population for two reasons. First, data is available only for

1966 and a very inaccurate method of adjustment would have to be devised if the 1950 and 1960 figures were to be adjusted accordingly. Secondly, though camp population, etc., are presently important parts of the population in many townships, their relative importance is expected to decline in the next 20 years. Much of the land now occupied by camps may be developed with housing or other intensive uses, and camps may be driven away from the main development areas.

Resorts, while expected to grow, will assume a small portion of the total population. Furthermore, it is felt that the logistic curve has the property of growing at a rate which should incorporate many of the concomitant conditions of resident (permanent and seasonal) population such as an increased number of resorts. However, in MCD's where resorts were thought to be especially important sectors of potential growth, the input figures were adjusted accordingly, to reflect their impact.

The second step in the projection procedure was to establish values for the two decision variables defined earlier in this section. The values for the magnitude of rate of growth were based on the expected growth of the New York metropolitan area, the expected demand for recreation, and the particular physical and economic characteristics of each MCD. The second decision variable, timing, was based on the assumption that growth would spread westward from the New York City and the northern New Jersey area and that this westward spread would be modified by less intense influences from existing population and recreation centers.

The two decision variables were used together with the historical data, to generate logistic curves for each MCD. Actually, a first set of curves used 1950-1960 growth data, a second set 1950-1966 data, and a third set 1960-1966 data. Because the last set was by far the most reasonable, it was selected as the best set.

The forecasts based on the 1960-1966 growth trends are presented in Tables F-11 and F-12. It should be noted that the population estimates in Table F-11 are for the total minor civil divisions which, in some cases, extend well beyond the geographical limits of the study area.

The general patterns of development reflected in these projections follow intuitive expectations rather closely. The growth in New Jersey is most rapid and many MCD's begin to experience declining growth rates well before the end of the projection period (2020). The increases in Sussex County exceed those in Warren County, though by the end of the period the gap is beginning to narrow.

The population growth in Pennsylvania begins more slowly, but by the middle of the study period the MCD's there are experiencing very high growth rates. Only a few of the Pennsylvania MCD's are experiencing significant declines in rate at the end of the period. Increases around Stroudsburg and, in particular, in Stroud, Middle

TABLE F-11
PEAK SEASON POPULATION PROJECTIONS BY
MINOR CIVIL DIVISION¹

(Exclusive of DWGNRA)

County	Township or Borough	Year					
		1970	1980	1990	2000	2010	2020
Pike	Blooming Grove Twp.	3,100	7,200	15,800	30,600	49,200	65,300
	Delaware Twp.	4,600	7,700	11,600	15,200	17,800	19,300
	Dingman Twp.	2,300	4,400	8,300	14,300	21,800	29,200
	Greene Twp.	3,900	6,200	9,800	14,900	21,900	30,700
	Lehman Twp.	4,500	7,800	12,900	20,100	28,700	37,500
	Matamoras Boro	3,100	4,100	5,200	6,400	7,600	8,600
	Milford Boro	2,000	2,800	3,500	4,300	5,000	5,500
	Milford Twp.	1,000	1,200	1,400	1,700	2,000	2,400
	Porter Twp.	900	1,100	1,400	1,700	2,100	2,500
	Shohola Twp.	4,000	8,300	15,400	25,000	34,400	41,200
	Westfall Twp.	2,900	5,600	10,000	16,400	23,700	30,300
Sub-Total:		32,300	56,400	95,300	150,600	214,200	272,500
Monroe	Barrett Twp.	7,500	10,500	14,600	19,800	26,100	33,400
	Chestnut Hill Twp.	5,800	10,700	17,300	24,000	29,000	32,100
	Coolbaugh Twp.	4,900	8,300	13,100	19,200	25,700	31,600
	E. Stroudsburg Boro	9,600	11,600	13,800	16,200	18,900	21,700
	Hamilton Twp.	5,100	6,800	8,900	11,700	15,200	19,500
	Jackson Twp.	4,500	9,500	17,400	26,400	33,600	37,700
	M. Smithfield Twp.	9,000	20,500	36,900	51,300	59,400	62,900
	Mt. Pocono Boro	1,800	2,300	3,000	4,000	5,100	6,700
	Paradise Twp.	5,100	10,100	18,100	27,900	36,800	42,900
	Pocono Twp.	3,800	5,500	8,000	11,300	15,600	20,700
	Price Twp.	900	1,500	2,700	4,700	7,900	12,600
	Ross Twp.	1,900	3,900	7,500	13,000	19,500	25,300
	Smithfield Twp. ²	8,000	14,300	23,800	35,400	46,300	55,800
	Stroud Twp.	10,500	14,200	19,200	25,500	33,300	42,600
	Stroudsburg Boro	7,300	8,600	10,100	11,800	13,700	15,800
	Tobyhanna Twp.	7,900	16,700	28,400	38,400	44,100	46,700
	Tunkhannock Twp.	1,500	4,800	11,600	18,900	22,700	24,100
Sub-Total:		95,100	159,800	254,400	359,500	453,400	532,100
Orange	Deerpark	9,200	15,000	19,000	20,900	21,600	21,800
	Greenville	2,200	3,800	5,900	8,700	11,700	14,400
	Mt. Hope	3,900	4,800	5,700	6,700	7,700	8,600
	Port Jervis	10,000	10,400	10,800	11,300	11,700	12,100
Sub-Total:		25,300	34,000	41,400	47,600	52,700	56,900

TABLE F-11
(continued)

PEAK SEASON POPULATION PROJECTIONS BY
MINOR CIVIL DIVISION¹

(Exclusive of DWGNRA)

County	Township or Borough	Year					
		1970	1980	1990	2000	2010	2020
Sussex	Andover Twp.	7,400	22,000	33,500	36,900	37,500	37,700
	Branchville Boro	1,400	1,900	2,600	3,300	4,100	4,900
	Frankford Twp.	9,000	15,300	22,800	29,300	33,700	36,300
	Fredon Twp.	2,800	6,300	11,900	17,700	21,700	23,600
	Hampton Twp.	7,100	16,200	24,400	28,100	29,300	29,600
	Lafayette Twp.	2,300	4,200	7,300	11,100	14,900	17,800
	Montague Twp.	3,600	8,100	14,700	20,900	24,600	26,200
	Newton	9,400	12,600	15,700	18,500	20,800	22,400
	Sandyston Twp.	6,500	9,800	13,900	18,600	23,300	27,500
	Sparta Twp.	19,300	31,800	46,100	58,900	67,900	73,300
	Stillwater Twp.	14,300	20,800	28,900	37,800	46,500	54,100
Sub-Total:		83,100	149,000	221,800	281,100	324,300	353,400
Warren	Blairstown Twp.	4,200	7,600	12,200	17,100	21,000	23,400
	Frelinghuysen Twp.	3,400	8,900	15,500	19,100	20,400	20,800
	Hardwick Twp.	2,500	8,500	15,600	18,600	19,300	19,400
	Knowlton Twp.	3,000	5,100	8,200	11,900	15,900	19,300
Sub-Total:		13,100	30,100	51,500	66,700	76,600	82,900
TOTALS:		248,900	429,300	664,400	905,500	1,121,200	1,297,800

¹ Values in this Table represent populations in the entire area of the minor civil division even though part of that area (with its population) may actually lie outside of the TIRES area.

² Because of its small size and population base, the Borough of Delaware Water Gap is combined with Smithfield Township for purposes of projecting population and demands for water supply and waste disposal.

TABLE F-12
PEAK SEASON POPULATION PROJECTIONS BY
DRAINAGE BASINS

(Exclusive of DWGNRA)

Drainage Basin	Year					
	1970	1980	1990	2000	2010	2020
PO-1	4,600	7,900	12,400	17,400	22,200	26,300
PO-2	1,300	2,400	4,500	7,500	11,300	14,800
PO-3	2,900	4,300	6,400	9,200	12,100	14,800
PO-4	6,200	9,400	14,200	20,400	27,300	33,400
PO-5	6,100	8,700	10,500	11,300	11,700	11,900
Sub-Total:	21,100	32,700	48,000	65,800	84,600	101,200
NE-1	15,200	20,600	25,900	29,900	32,500	34,100
NE-2	1,100	2,400	4,400	6,300	7,400	7,900
Sub-Total:	16,300	23,000	30,300	36,200	39,900	42,000
FL-1	8,000	12,900	19,500	26,400	32,500	37,300
FL-2	200	400	700	1,000	1,200	1,200
Sub-Total:	8,200	13,300	20,200	27,400	33,700	38,500
BU-1	8,500	16,100	27,500	40,000	51,500	61,300
BU-2	2,000	3,400	5,700	8,500	11,800	14,900
BU-3	2,700	4,700	7,400	10,900	14,600	18,200
Sub-Total:	13,200	24,200	40,600	59,400	77,900	94,400
BR-1	11,700	19,700	31,600	45,200	57,200	66,300
BR-2	10,400	15,000	21,400	29,300	37,500	45,900
BR-3	15,000	24,200	37,700	54,400	71,600	87,400
BR-4	11,400	17,600	26,700	39,200	55,400	75,200
BR-5	16,100	22,900	32,100	42,800	53,700	64,000
BR-6	11,400	19,700	31,500	43,400	52,600	58,900
Sub-Total:	76,000	119,100	181,000	254,300	328,000	397,700
CH-1	3,800	5,100	6,900	9,100	11,800	15,200
Sub-Total:	3,800	5,100	6,900	9,100	11,800	15,200
KI-1	600	1,000	1,600	2,400	3,200	3,900
Sub-Total:	600	1,000	1,600	2,400	3,200	3,900
PA-1	4,600	8,900	14,700	20,000	24,200	27,100
PA-2	9,300	19,000	31,000	39,300	44,700	48,400
PA-3	10,500	17,300	24,600	30,800	36,100	40,500
PA-4	29,800	52,400	76,300	95,000	108,100	116,600
Sub-Total:	54,200	97,600	146,600	185,100	213,100	232,600
TOTALS:	193,400	316,000	475,200	639,700	792,200	925,500

Smithfield, and Smithfield Townships, are most rapid. The Pocono Lakes area also experiences significant population growth.

The New York MCD's are the slowest to begin growth and most of them are still increasing at their maximum rates of growth at the end of the period.

To evaluate further the population growth of each MCD in relation to its neighbors, the population estimates were translated into population densities on the basis of net usable acres of land (see Appendix B). These densities, presented in Tables F-13 and F-14 are not to be considered as development densities but, rather, are meant to reflect only the gross density of population at peak usage. The densities on the New Jersey side are generally the highest, as might be expected. Pennsylvania densities decline with distance from the DWGNRA, although the area around the Pocono Lakes has a significant level of development by 2020. The Stroudsburg area shows the most intense development in Pennsylvania. The New York area, other than Port Jervis, shows the lowest level of development.

Seasonal and permanent population and housing.--A final consideration was to provide some indication of the proportion of population that will be seasonal in each of the counties. The estimates are analytically independent of the peak season forecasts and are presented in Table F-15.

The discussion presented herein is primarily based on recent surveys by the DRBC. Because this survey information and all previous source data on the permanent-seasonal split is in terms of housing units rather than persons, the presentation herein is also in terms of housing units.

The Nathan report, on the basis of past trends, indicates that the ratio of seasonal to permanent housing in the area will be one-to-one. In light of the recent data collected by the DRBC, this ratio requires adjustment. The increase in retirement communities and in commutation from Sussex County, together with the continued large percentage of homes being built for all-weather use, indicates that the percentage of seasonal homes in Sussex County to be expected by 1990 would be no more than 35 percent; by the year 2020 this percentage should decline to 25 percent.

In Warren County, recreation demand has grown rather slowly. However, with the construction of Interstate 80 and the completion of the DWGNRA, a rapid surge in recreational growth can be expected. The accessibility provided by I-80, however, will make this area competitive with most of Sussex County as a commuter residence. For this reason, the early surge in recreational demand will level off as more and more people choose Warren County for permanent residence.

Pike and Monroe Counties are expected to be predominantly seasonal areas for the extent of the projection period. They will absorb

TABLE F-13

PEAK SEASON POPULATION DENSITY PROJECTIONS BY MINOR CIVIL DIVISION
(Exclusive of DWGNRA; Persons Per Acre)

County	Township or Borough	1966	1970	1980	1990	2000	2010	2020
Pike	Blooming Grove Twp.	0.065	0.101	0.239	0.525	1.018	1.639	2.174
	Delaware Twp.	0.186	0.254	0.440	0.664	0.870	1.016	1.102
	Dingman Twp.	0.058	0.082	0.162	0.304	0.522	0.798	1.070
	Greene Twp.	0.095	0.121	0.194	0.304	0.465	0.684	0.958
	Lehman Twp.	0.171	0.227	0.393	0.651	1.012	1.449	1.893
	Matamoras Boro	4.917	5.753	7.672	9.834	12.077	14.213	16.089
	Milford Boro	6.181	7.351	10.011	12.897	15.697	18.130	20.052
	Milford Twp.	0.137	0.149	0.177	0.211	0.251	0.299	0.355
	Porter Twp.	0.050	0.056	0.071	0.088	0.109	0.133	0.160
	Shohola Twp.	0.137	0.201	0.414	0.773	1.252	1.721	2.062
	Westfall Twp.	0.127	0.178	0.341	0.613	1.002	1.450	1.854
Monroe	Barrett Twp.	0.217	0.258	0.364	0.505	0.686	0.906	1.160
	Chestnut Hill Twp.	0.180	0.253	0.469	0.760	1.053	1.274	1.407
	Coolbaugh Twp.	0.185	0.244	0.409	0.649	0.952	1.277	1.568
	E. Stroudsburg Boro	5.491	6.034	7.244	8.617	10.148	11.818	13.598
	Hamilton Twp.	0.181	0.209	0.277	0.365	0.478	0.621	0.800
	Jackson Twp.	0.218	0.327	0.690	1.265	1.920	2.437	2.740
	M. Smithfield Twp.	0.213	0.340	0.770	1.366	1.927	2.234	2.366
	Mt. Pocono Boro	0.742	0.850	1.112	1.452	1.892	2.456	3.175
	Paradise Twp.	0.269	0.389	0.775	1.386	2.137	2.819	3.287
	Pocono Twp.	0.143	0.174	0.256	0.370	0.524	0.722	0.960
	Price Twp.	0.066	0.089	0.159	0.281	0.487	0.820	1.315
	Ross Twp.	0.088	0.128	0.265	0.512	0.889	1.333	1.725
	Smithfield Twp. ¹	0.471	0.644	1.158	1.921	2.862	3.785	4.510
	Stroud Twp.	0.449	0.526	0.717	0.966	1.284	1.676	2.143
	Stroudsburg Boro	5.836	6.358	7.518	8.835	10.314	11.950	13.732
	Tobyhanna Twp.	0.168	0.259	0.548	0.932	1.258	1.445	1.530
	Tunkhannock Twp.	0.038	0.070	0.221	0.534	0.867	1.045	1.107
Orange	Deerpark	0.152	0.216	0.351	0.445	0.488	0.505	0.511
	Greenville	0.085	0.112	0.188	0.298	0.437	0.587	0.721
	Mt. Hope	0.211	0.236	0.291	0.350	0.411	0.471	0.527
	Port Jervis	5.414	5.532	5.772	6.013	6.256	6.500	6.744
Sussex	Andover Twp.	0.270	0.574	1.711	2.607	2.868	2.918	2.927
	Branchville Boro	3.419	4.033	5.516	7.338	9.444	11.714	13.983
	Frankford Twp.	0.317	0.432	0.737	1.094	1.407	1.622	1.745
	Fredon Twp.	0.149	0.236	0.537	1.017	1.515	1.849	2.012
	Hampton Twp.	0.268	0.464	1.063	1.598	1.839	1.914	1.935
	Lafayette Twp.	0.137	0.192	0.360	0.620	0.949	1.274	1.523
	Montague Twp.	0.150	0.238	0.538	0.980	1.391	1.635	1.745
	Newton	4.166	4.914	6.539	8.178	9.644	10.818	11.681
	Sandyston Twp.	0.598	0.743	1.112	1.582	2.116	2.650	3.120
	Sparta Twp.	0.591	0.788	1.299	1.885	2.407	2.777	2.997
	Stillwater Twp.	0.666	0.816	1.190	1.649	2.157	2.654	3.089
Warren	Blairstown Twp.	0.153	0.213	0.387	0.623	0.871	1.069	1.195
	Frelinghuysen Twp.	0.126	0.227	0.595	1.031	1.277	1.362	1.386
	Hardwick Twp.	0.106	0.224	0.753	1.380	1.644	1.707	1.720
	Knowlton Twp.	0.152	0.201	0.339	0.540	0.789	1.050	1.277

¹Includes Borough of Delaware Water Gap.

TABLE F-14

PEAK SEASON POPULATION DENSITY PROJECTIONS BY DRAINAGE BASINS
(Exclusive of DWGNRA; Persons Per Acre)

<u>Drainage Basin</u>	<u>1966</u>	<u>1970</u>	<u>1980</u>	<u>1990</u>	<u>2000</u>	<u>2010</u>	<u>2020</u>
PO-1	.3381	.4585	.7942	1.2413	1.7393	2.2194	2.6318
PO-2	.0888	.1757	.2449	.4495	.7543	1.1263	1.4848
PO-3	.2370	.2889	.4324	.6420	.9152	1.2127	1.4785
PO-4	.4963	.6162	.9454	1.4225	2.0445	2.7281	3.3395
PO-5	.4895	.6106	.8659	1.0450	1.1336	1.1732	1.1934
NE-1	1.2839	1.5156	2.0646	2.5901	2.9879	3.2456	3.4073
NE-2	.0680	.1076	.2434	.4438	.6293	.7401	.7899
FL-1	.6210	.7986	1.2908	1.9472	2.6426	3.2505	3.7298
FL-2	.0106	.0168	.0380	.0693	.0982	.1155	.1233
	6.4768	6.4768	6.4768	6.4768	6.4768	6.4768	6.4768
BU-1	.6069	.8470	1.6123	2.7485	4.0046	5.1503	6.1281
BU-2	.1490	.1979	.3447	.5672	.8540	1.1755	1.4905
BU-3	.2003	.2692	.4652	.7439	1.0892	1.4638	1.8174
BR-1	.9019	1.1665	1.9681	3.1607	4.5239	5.7169	6.6261
BR-2	.8712	1.0379	1.4965	2.1458	2.9267	3.7468	4.5862
BR-3	1.1779	1.4972	2.4177	3.7694	5.4415	7.1624	8.7401
BR-4	.9164	1.1413	1.7624	2.6721	3.9208	5.5390	7.5191
BR-5	1.3625	1.6130	2.2885	3.2068	4.2761	5.3661	6.4013
BR-6	.8689	1.1378	1.9717	3.1537	4.3425	5.2586	5.8887
CH-1	.3277	.3814	.5140	.6869	.9080	1.1837	1.5171
	8.5436	8.5436	8.5436	8.5436	8.5436	8.5436	8.5436
KI-1	.0462	.0610	.1032	.1639	.2397	.3190	.3878
PA-1	.3219	.4583	.8925	1.4681	2.0028	2.4218	2.7070
PA-2	.6501	.9274	1.9014	3.1016	3.9340	4.4666	4.8357
PA-3	.7965	1.0467	1.7252	2.4568	3.0837	3.6141	4.0527
PA-4	2.1886	2.9836	5.2394	7.6333	9.4966	10.8062	11.6597

TABLE F-15

ESTIMATED PERCENT OF TOTAL HOUSING IN SEASONAL USE

<u>County</u>	<u>1960¹</u>	<u>1990</u>	<u>2020</u>
Sussex	40.8	35.0	25.0
Warren	20.2	40.0	45.0
Pike	54.4	60.0	60.0
Monroe	33.6	45.0	50.0
Orange	12.5	50.0	50.0

¹Based on Tables F-9 and F-10.

much of the recreational demand that is now being satisfied in Sussex. Pike County will remain relatively isolated from the large surges of permanent population that are expected in the TIRES area if present transportation plans are followed. Consequently, the percent of seasonal population will be sustained at a high level. Monroe, however, will experience an impact from the existence of I-80 and, as a result, the percentage of seasonal population should level off at a lower level than is expected in Pike County.

Orange County will be influenced by Sullivan County to the north, a major recreation area, and by the reservoir to the south. It should reach a high level of seasonal population toward the middle of the projection period and sustain this percentage.

FUTURE ECONOMIC ACTIVITIES

The economic activities of the TIRES area have been projected to the year 2000 in this study. This was done on a county-wide basis, using the same four counties that were previously discussed in the section regarding the present economy. The projections assumed that the impact of the DWGNRA began to take effect between 1959 and 1965. This is a reasonable assumption because the proposal for constructing the Tocks Island dam was announced as early as 1960 by the U. S. Army Corps of Engineers, and land values subsequently began a marked rise.

Using data obtained from County Business Patterns, industrial classifications were studied for changes through the six-year period between 1959 and 1965. Annual changes were calculated for employment, payrolls, and the number of units, and projections made. The annual changes were used to yield the changes which will occur between 1965 and 1985. The changes during this 20-year period were added to the 1965 figures to yield estimates of employment, payrolls, and number of units in 1985. In some cases where the estimates were most unusual, adjustments were made using information from local, county, and state reports and statistics. Resulting projections for 1985 employment, payrolls, and number of units for ten industrial classifications are given in Table F-16.

Future employment in the tourist and vacation industry was more intensely studied because of the specialized activities created by the DWGNRA. Projections are made for the five key counties and their areas in the TIRES area. Robert R. Nathan Associates (1965) did a similar study in the counties adjoining DWGNRA on the number of establishments that could be supported by DWGNRA visitors. Their estimates are based on estimated visits and expenditures and are presented in Table F-17.

The method used in the TIRES examined the total growth potential of the TIRES area, not just the potential establishments generated by the DWGNRA. Employment in the tourism and vacation industries of the TIRES area was examined by using a ratio-projection method. The number of persons employed in eating and drinking establishments, personal services, and entertainment and vacation classifications were obtained from the 1960 U. S. Census for each county within the TIRES area. These three classifications are considered to comprise the tourism and vacation industries. The number employed in each classification was then divided by the 1960 population (the same was done for the total of the five counties) yielding employment per capita ratios for the tourism and vacation activities in the counties. These data are shown in Table F-18.

The 1960 population of each county was obtained from U. S. Census data and the percentage of that population within the TIRES area was calculated. This percentage was then multiplied by the number of people employed in the three classifications for each county to

TABLE F-16

1985 REGIONAL ECONOMY BY COUNTY

	<u>WARREN</u>			<u>SUSSEX</u>			<u>PIKE</u>			<u>MONROE</u>		
	<u>No. of Employees</u>	<u>Payrolls</u>	<u>Units</u>	<u>No. of Employees</u>	<u>Payrolls</u>	<u>Units</u>	<u>No. of Employees</u>	<u>Payrolls</u>	<u>Units</u>	<u>No. of Employees</u>	<u>Payrolls</u>	<u>Units</u>
Agriculture	90	119	5	60	81	20	-	-	9	150	200	25
Mining	-	-	2	100	850	3	-	-	-	58	68	3
Construction	1005	2264	88	820	1,349	226	449	695	52	1,341	1,761	83
Manufacturing	14,295	26142	138	4,199	7,754	114	390	395	50	7,519	11,326	99
Transp. Utilities	1833	3414	108	1,572	2,442	170	91	88	16	425	500	50
Wholesale	500	600	43	230	294	55	66	50	9	200	300	28
Retail	5,442	5,125	504	4,041	2,000	622	1,350	1,300	200	3,150	3,256	345
Finance, Insurance	559	782	98	1,600	2,241	132	120	257	40	517	605	94
Service	3,161	3,384	379	3,165	6,168	458	587	1,184	99	2,800	3,000	350
Unclassified	-	-	15	40	33	19	-	-	5	15	20	5
1985 TOTALS:	25,937	40,826	1,315	16,187	23,507	2,301	2,345	3,039	287	17,885	23,079	1,358
1965 TOTALS:	18,000	22,000	1,000	9,000	10,000	1,000	1,300	1,400	251	10,900	10,600	1,000
Net Change:	7,937	18,826	315	7,187	13,507	1,301	1,045	1,639	36	7,985	12,479	358

Source: Consultant's projection

TABLE F-17
ESTIMATED NUMBER OF ESTABLISHMENTS
SUPPORTED BY DWGNRA VISITORS

FOOD		
Restaurants		40 - 80
Grocery Stores		2 - 3
LODGING		
Transient		50 - 95
TRANSPORTATION		
Motor vehicle service stations		25 - 50
MISCELLANEOUS		35 - 60

Source: Robert R. Nathan Associates (1965)

TABLE F-18
1960 EMPLOYMENT AND EMPLOYMENT PER CAPITA IN THE TOURISM
AND VACATION INDUSTRY OF EACH COUNTY

COUNTY	<u>Employment</u>			TOTAL	1960 Population	<u>Employment Per Capita</u>		
	Eating & Drinking	Other Personal Services	Entertain & Recreation			Eating & Drinking	Other Personal Services	Entertain & Recreation
Pike	120	210	41	371	9,158	.01310	.02293	.00447
Monroe	522	1,447	104	2,073	39,567	.01319	.0357	.00262
Sussex	540	306	77	923	49,255	.01102	.00624	.00157
Warren	725	553	109	1,387	63,220	.01150	.00877	.00173
Orange	1,719	2,000	411	4,130	183,734	.00935	.01088	.00223
Total	3,626	4,516	742	8,884	344,425	.01052	.01311	.00215

SIC 58 SIC 72 SIC 79
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Source: County Business Patterns
Consultant's Calculations

obtain the number employed in the TIRES area. This assumes that the percent of those employed in the tourism industry of the watershed area of each county will be the same as the percentage of the total tourism employment of each county. Ratios of per capita employment were then calculated and are shown in Table F-19.

Using 1960 U. S. Census data, employment in the tourism and vacation industries and ratios of per capita employment were then calculated for (1) the United States¹, (2) Sullivan County, New York, (3) Greenbrier County, West Virginia², (4) Cape Cod, Massachusetts, and (5) the tri-state area including Pennsylvania, New Jersey and New York. These data are presented in Table F-20. The TIRES area could then be compared to the vacation industry in the other areas. It was assumed, when the DUGIRA was fully operational, the level of tourism employment in the TIRES counties would be brought to a level comparable to these other areas.

Table F-21 shows the projections of employment in the tourism and vacation industries of the TIRES area from 1970 to 2000, assuming that Tocks Island tourism will reach the economic maturity now present in the various other tourist areas. Utilizing estimates of the future populations at ten-year intervals, several projections were made based on different assumptions; the TIRES area employment in the vacation industry (a) would by 2000 reach the level of current vacation industry employment equal to Sullivan County, New York (the large and established Catskills resort area that characterizes now what the Tocks Island Region will likely become), (b) would by 1990 reach a level of current vacation industry employment equal to Greenbrier County, West Virginia, and (c) would by 1990 reach a level of current vacation industry employment equal to an average between Cape Cod, Massachusetts and Greenbrier County, West Virginia.

Table F-22 shows the number of people employed in the recreation industry of the TIRES counties, the number of tourism and vacation oriented establishments, and the average number employed in each type of establishment. It is assumed that the number employed per establishment will be the same for both the five-county area and the TIRES area. Thus, per establishment in the watershed area, there are approximately 4.33 persons employed in eating and drinking establishments; 3.2 persons employed in personal services; and 3.96 persons employed in entertainment and recreation.

The number of tourist and vacation establishments will continue to grow but, after 1985, at a slower rate. Employment and income of the recreation-based industries is expected to level off. The upward spiraling population of the New York and Philadelphia metropolitan

¹Data obtained from Regional Science Research Institute

²Ibid.

TABLE F-19

1960 EMPLOYMENT AND EMPLOYMENT PER CAPITA IN THE TOURISM
AND VACATION INDUSTRY IN THE AREA OF EACH COUNTY IN THE
STUDY AREA

TIRES Area of Each County	Employment		Other Personal Services	Entertain & Recreation	TOTAL	1960 Population	Employment Per Capita		
	Eating & Drinking	Other Personal Services					Eating & Drinking	Other Personal Services	Entertain & Recreation
Pike	76	132		25	234	5,809	.01308	.02272	.00430
Monroe	407	1,129		81	1,617	30,998	.01312	.03642	.00261
Sussex	162	92		23	277	15,025	.01028	.00612	.00153
Warren	36	28		5	69	3,572	.01007	.00783	.00139
Orange	34	40		8	82	12,363	.00275	.00323	.00113
TOTAL	715	1,421		142	2,279	67,767	.01055	.02096	.00209

Source: Consultant's Calculations

TABLE F-20

1960 EMPLOYMENT AND EMPLOYMENT PER CAPITA IN THE TOURISM
AND VACATION INDUSTRY FOR THE U.S. AND SELECTED AREAS

	<u>Employment</u>			<u>Employment Per Capita</u>					
	Eating & Drinking	Other Personal Services	Entertain & Recreation	TOTAL	1960 Population	Eating & Drinking	Other Personal Services	Entertain & Recreation	TOTAL
U.S. Total	1,802,000	1,942,000	502,879	4,247,000	179,323,000	.01004	.01088	.00280	.02367
Sullivan Co., N.Y.	561	1,974	154	2,689	45,272	.01239	.04355	.00340	.05939
Greenbrier Co., W. Va.	279	1,274	108	1,661	34,446	.00809	.03698	.00313	.04822
Cape Cod	757	1,027	208	1,992	70,286	.01077	.01461	.00295	.02834
Tri-State* Total	470,027	652,117	106,574	1,228,718	34,168,192	.01375	.01908	.00311	.03596

Source: Consultant's Calculations

*New York, New Jersey and Pennsylvania

TABLE F-21

NUMBER AND PER CAPITA EMPLOYMENT IN THE TOURIST AND RECREATION
INDUSTRY OF THE TOCKS ISLAND AREA

	<u>1970</u>	<u>1980</u>	<u>1990</u>	<u>2000</u>
Permanent Population Estimates of TIRES area	156,700	259,800	366,300	482,800
TIRES area				
A. Per Capita Tourist Employment ¹	.03877	.04392	.04907	.05422
Number Employed	6,075	11,410	17,974	26,177
B. Per Capita Tourist Employment ²	.03842	.04322	.04822	0.5302
Number Employed	6,020	11,228	17,662	25,598
C. Per Capita Tourist Employment ³	.03512	.03662	.03828	.03978
Number Employed	5,503	9,513	14,021	19,205

¹Per capita recreation employment level of Sullivan Co., N.Y. by 2010.²Per capita recreation employment level of Greenbrier Co., W.Va. by 1990.³Per capita recreation employment level of average between Greenbrier and Cape Cod by 1990.

TABLE F-22

SELECTED EMPLOYMENT PER ESTABLISHMENT
IN THE TOURISM AND VACATION INDUSTRY
IN THE TOCKS ISLAND COUNTIES
1963

	<u>Eating and Drinking</u>	<u>Personal Service</u>	<u>Entertainment and Recreation</u>	<u>Total</u>
No. Employed	4,474	5,372	844	10,690
Percent of Total No. Employed	.42	.50	.08	100
No. of Establishments	1,034	1,678	213	2,925
No. Employed per Establishment	4.33	3.20	3.96	3.65

Source: 1963 Census of Business

areas will assure that the number of new tourist facilities will continue to increase, although the visitor capacity of the DWGNRA itself is limited.

The data presented in the previous tables illustrates alternative levels of resort-based employment as the TIRES area grows in response to DWGNRA as compared with the relationships that exist in current major resort counties. It is clear that the opening of DWGNRA will produce a substantial region-wide effect on the resort and recreation facilities throughout the TIRES counties. The magnitude of growth is still largely conjectural because the impact is just beginning to be felt, and local land use patterns and economic policies are still in the formative stages.

FUTURE TRANSPORTATION SYSTEMS

Planned highway improvements

Numerous new highways and improvements of old roads are proposed for the counties of the DMGHRA region. Inventoried below are proposals compiled from various sources; some complimentary, some contradictory.

The significance of a properly placed highway network in the TIRES area cannot be understated. If the livelihood of the region is to depend upon the tourist trade from neighboring metropolitan areas, it must be readily accessible to auto traffic from these centers.

Highway transportation will be the most important mode of travel throughout the TIRES area. Realizing that the present highway system will not be able to accommodate the projected traffic volumes after the National Recreation Area is opened, state and local governments of the area have proposed plans for highway improvements well before the actual need. A summary of the planned highway improvements tentatively programmed for the TIRES area follows.

Pennsylvania highways.--The Pennsylvania Department of Highways Six-Year Improvement Program evolved from suggestions by state legislators, local government officials, planning commissions, motor clubs, industry, quasi-public bodies, local citizens, and the District Office of the Pennsylvania Highway Department.

The program includes the following major proposals:

1. Relocate 24.8 miles of Route 209 and 6 in Pike County and 12.7 miles of Route 209 in Monroe County.
2. Reconstruct 5.5 miles of Routes 490 and 423 from Tobyhanna (Monroe County) to Wayne County, as a 24-ft. wide road.
3. Reconstruct 8 miles of Route 106 from Mt. Pocono (Monroe County) to Wayne County, as a 22-ft. wide road.

The program also proposes many minor road improvements (tree removals, bridge improvements, signalization, etc.) for Pike and Monroe Counties, principally to enhance highway safety.

The Bureau of Advance Planning of the Pennsylvania Department of Highways in a special report, "Highway Impact Study--Delaware Water Gap National Recreation Area," presents recommendations for future highways based on evaluation of present land development potential, current travel patterns, and levels of service for those Pennsylvania highways affected by DMGHRA.

By 1990 the Bureau proposes:

1. Widening of 6 miles of Routes 45061 and 461-E, from Route 209 to Coolbaugh, to 24 feet.
2. Construction of a new 16-mile, 2-lane road (on a 4-lane realignment) from Route 15 at Windgap to Portland.
3. Widening of 14 miles of Routes 940, 191 and 447, from Route 611 at Mt. Pocono to the intersection of Routes 447 and 209, to 48 feet.
4. Addition of two lanes to 16 miles of Interstate Route 80, from Interstate Route 81-E to the Delaware River (16 miles).

Raymond and May Associates (1966) undertook a study of the highway system in the TIRES area; recommendations in their report included:

1. Construct a highway in Pike County from Dingmans Ferry to Porters Lake, and then southwest to connect with the Pocono resorts and Route I-81E. Toward Monroe County, it would feed traffic to Interstate Routes 81-E and 80.
2. Construct a by-pass on Route 209 around the Stroudsburg urban area.
3. Construct five interchanges on Route I-84; two of which are of critical importance: an interchange between Matamoras and Milford and one west of Milford. Three additional interchanges are planned for the western portion of Pike County, but further investigations should be conducted particularly with reference to a possible interchange to be located at Lords Valley.
4. Construct a connecting link between Routes I-84 and I-80 in the western part of the two-county area similar to the linkage provided by Route 209.
5. Route 423 should be improved and extended to become a final link in a loop system of highways around Pike and Monroe Counties.
6. A re-statement of recommendations of the Joint Planning Commission of Lehigh-Northampton Counties:
 - a) Relocation of U. S. Route 611 as a vital connecting link from the south to Interstate 80.

- b) Construct a Slate Belt Expressway to improve access between Windgap and Portland that would permit convenient travel to the National Recreation Area and Interstate 80.

The Pennsylvania State Planning Board report "Regional Development Reconnaissance for Region 3" (Wayne, Pike, and Monroe Counties)" contains a brief section on highway needs and transportation planning. The report notes that Interstates 80 and 84 will provide access to both ends of the Tocks Island Recreation Area.

Interstate 81-E, paralleling U. S. Route 611, will eventually connect Scranton with Interstate 80, and to complete the Region's interstate network will be Interstate 84 which enters the state at Matamoras and crosses central Pike and the southern tip of Wayne. U. S. Route 209, winding along the Delaware from Stroudsburg to Matamoras will have to be relocated when the reservoir is created. Interest in recreation and scenic highways has spurred efforts to revive the 25-year old Pocono Mountains Memorial Parkway idea.

This report also contains a summary of other new highways and improvement to old roads previously mentioned.

In addition to highway improvements required for access to and from and movement within the overall TIRES area, several local studies have been conducted at the township level on ways to improve traffic patterns, and to discourage through traffic from traveling on township roads. These reports were reviewed for this study but are not summarized herein due to their limited importance.

New Jersey highways.--Several studies have been conducted which include proposals for Sussex and Warren Counties. In Raymond and May Associates (1966), the following were recommended:

1. Construct a new parkway. The Foothills Highway, to extend from Interstate 84 in New York to Interstate 80 in New Jersey.
2. Construct the Walpack Parkway from Interstate 80 to Walpack Bend to handle recreational traffic.
3. Construct an East-West Highway from Route 23 at Franklin to Sparta, Newton, and Walpack that could be used as an alternate route to Interstate 80 and Walpack Parkway.
4. Construct a Montague Highway from south of Montague to Route 23 near I-84 as an access highway to the Interstate system and the National Recreation Area.

5. Relocate Route 206 from I-80 north to Milford, Pennsylvania to provide a major bypass to the east of Newton and access to Namanock, Tom Quick, and Flatbrook sites in DWGNRA.
6. Improve State Route 23 from Franklin to Route I-84. As an expressway, it would provide a major distribution function for recreational sites and the region at large.
7. Improve State Route 15 from Lake Hopatcong to U. S. Route 206 to serve as an alternative for westbound traffic using Route I-80.
8. Widen State Route 94 to serve as a northeast-southwest distribution link.

The New Jersey Transportation Department outlined a "New Jersey Draft Highway Network" that is very similar to Raymond and May's plan. It is not yet an official program of the Department. Differences with the "Sketch Plan" exist on the finer points such as precisely where two roads should merge. Projects included are the following:

1. Widen State Route 94 from Columbia to Newton.
2. Widen U. S. Route 46.
3. Construct sections of the Foothills Highway from State Route 206 north to State Route 23 at I-84.
4. Tie-in the south end of the Foothills Highway from State Route 69.
5. Construct a freeway from State Route 206 north to 94, east of Newton.
6. Relocate State Route 23 as a freeway and a Sparta-Woodport bypass.
7. Reconstruct State Route 23 into a freeway.

In the Sussex County Transportation and Circulation Summary, it is noted that by 1975 the following projects are to be undertaken:

1. Dualize Route 206.
2. Widen Route 94.
3. Improve Routes 15 and 23 since they are anticipated to become major feeder highways once the Interstate 80 interchange is opened.

4. Complete Interstate 80 early in the 1970's.
5. Construct four interchanges on Interstate 80 in Warren County at County Routes 517, 519, 521 and at Columbia in Knowlton Township.
6. Widen Route 94 to four lanes.
7. Construct the Tocks Island Parkway to provide access to recreational sites along the Delaware River.

New York highways.--In the "Town of Deerpark Development Plan," Raymond and May associates recommended the following:

1. Reconstruct Route 209 from Port Jervis north to Sullivan County, generally following the abandoned Ontario and Western rail bed.
2. Redesign the interchange of I-84 and New Jersey Route 23 and New York Route 6.
3. Construct a highway along the abandoned Delaware and Hudson Canal bed, and tied-in with the Delaware Feeder Route and the redesigned interchange at I-84.

Traffic in the TIRES area.

The various attractions within the DWGNRA will be tremendous generators of highway traffic. The Master Plan for DWGNRA offers a detailed inventory of all the roads by which these various recreation areas can be reached. The Plan notes that:

"...in the original Plan the estimated annual visitation will be 10.5 million with a design load of 141,000 by 1975. Both of these estimates were based on a preliminary survey type analysis of the carrying capacity of the recreation area with the assumption that the recreation demand generated within the service area of the project is far in excess of the potential supply of this area."

The Bureau of Advanced Planning of the Pennsylvania Department of Highways estimates that by 1990 there will be approximately 16,600,000 annual visitors. Approximately 55 percent will come from metropolitan areas of New York and New Jersey, about 25 percent from the Philadelphia-Trenton area, 12 percent from less populated areas, and 8 percent from counties contiguous with the DWGNRA. The Bureau of Advanced Planning adds:

"It is anticipated the majority of the visitors will drive by private automobile to the DWGNRA, spend a few hours and return home on the same day. The activities, needs, expenditures, and tastes for a daily visit by a typical family will be quite different from those of the two-week resort client or the summer season resident. As a result, the highway facilities serving the DWGNRA should be planned and designed for this type of visitation."

Although the highways of the TIRES region are inadequate to facilitate movement of the projected volumes of traffic, several plans for needed improvements have been completed. These highway plans have been proposed on regional, county and local levels in anticipation of the onslaught of seasonal tourist visitors.

Implementation of all levels of these highway plans is essential. The prosperity and preservation of the rural character of the local areas can best be perpetuated by moving the projected large volumes of tourist traffic with as few obstacles as possible. For optimum development of the region, all highway plans should be closely coordinated to the extent possible with all existing comprehensive land use plans.

It was beyond the scope of this study to formulate additional highway programs. Rather, existing proposals were reviewed and evaluated and their effects on the location of population centers was taken into consideration.

FUTURE LAND USE

Comprehensive land use studies

Planning future land use in the TIRES area emerged as essentially a government process in 1960 when the U. S. Army Corps of Engineers completed their report regarding flood control on the Delaware River and its tributaries.

Few counties and MCD's in the region had begun comprehensive plans prior to the announcement of the proposal for the dam and National Recreation Area. None were able to take into consideration the impact this recreational facility would have upon their communities.

Because the chief purpose of this report is a feasibility study on establishing long-range utility needs and services, no exhaustive study was made on optimum future use of the land. In this study, the Raymond and May (1966) Sketch Plan was updated to conform more realistically to current land use and recent subdivision activity. However, the basic Sketch Plan with its underlying assumptions was adopted for this study in the preparation of utilities' plans.

The Raymond and May Associates (1966) recommend an extensive system of open space to preserve the quantity and quality of forests and natural features in the TIRES area. Open space serves as a significant force in defining and giving form to development areas, and can be achieved on both the regional and community scale. The Raymond and May Associates' discussion of their system includes:

1. Waterways form the skeleton of the open space system; thus, regulation of all waterways and control of their shores are essential to retain the natural values of the area. The National Recreation Area will preserve and enhance a portion of the Delaware River. Under utility company control, development at Lake Wallenpaupack is regulated. If to these major waterways were added regulation of the numerous streams, creeks, and lakes, a large part of a regional system of open space could be established.
2. Expand publicly owned land in the Region. Under the Green Acres program, New Jersey has already acted in this direction and only limited further acquisitions by the State are recommended at this time. Current plans for expansion of the present large State holdings, such as High Point State Park, Stokes State Forest and Swartswood State Park, would increase the amount of publicly owned land in the Jersey portion of the Region to about 75 square miles (or 15% of the New Jersey portion of the Regional area).

3. Solidify and interconnect present State holdings. The State of Pennsylvania has acquired open space areas throughout the State under its Project 70 program. It now controls over 200 square miles (or about 18 percent) of the total land area in Pike and Monroe Counties.

It is suggested that in selected areas these forests, game lands and parks be gradually extended to provide continuity and preserve the integrity and value of existing public holdings. Such expansion need not necessarily involve much developable land; indeed, unbuildable ridges, gorges, and swamps could provide the links between many existing State areas. Within the present holdings there are many small pockets of buildable land accessible only by roads through State lands. In instances where these pockets already adjoin existing highways, their development will only increase traffic through State property. Careful planning of roads can therefore act as a deterrent to further development and to spread of high density, seasonal residences of sub-standard quality."

The proposed open space system would almost double the amount of open space in the Pennsylvania sector. The basic components of the system include: 1) the DMGHRA; 2) existing state forests and game lands; and 3) unbuildable ridges, gorges, swamps, and lands bordering streams and rivers. Although the proposed open space system is distributed throughout Pike and Monroe Counties, the fact that the major state and anticipated Federal holdings are located in the northern portion of the region results in a large share of the conservation areas being located in Pike County. Monroe County is now, and is likely to continue to be, the more dominant location for commercial, recreation, and other urban activities not only for the Pennsylvania areas but for the entire region.

In view of the existing large state parks and the topographic character of the remaining area, only a few extensions of open space, in addition to those already contemplated, are proposed for the New Jersey sector of the region. However, it is proposed that measures be undertaken to limit urban development in much of the agricultural areas which lie between community developments in Sussex and Warren Counties.

State and utility lands.--The state parks in the TIRES area are few in number but large in size. On the New Jersey side of the River are High Point State Park and Stokes State Forest; the Pennsylvania side includes Tobyhanna, Delaware, Big Pocono, and Promised Land State Parks. Utility lands are included in the state land category because they function in much the same manner as state-owned open space. The utility lands in the region are predominantly watershed areas for nearby cities and towns.

Other open space.--Other lands that should remain as open space include childrens' camps, resort holdings, gun clubs, and other private and semi-private agents. The number of camps, clubs, and resorts have been increasing in recent years and will probably continue to do so as the TIRES area becomes more vacation-oriented. These private and semi-private uses added to the DUGHERA, the recommended open space, and the state park and utility lands, complete the vast network of open space that is interlaced throughout the entire TIRES area.

Existing development.--Areas that are presently developed are expected to be the most densely settled in the future. The urbanized centers of Stroudsburg, Port Jervis, and Newton are expected to become three primary regional centers. These will continue to function as regional centers because of their location, political importance, and established economy. There are eight other proposed regional centers on a somewhat smaller scale; they are Sussex, Branchville, Blairstown, Columbia, and Montague in New Jersey and Dingman's Ferry, Bushkill and Milford in Pennsylvania. Third-level settlements or rural town centers are identified as areas which would have from 200 to 300 houses. Typical areas include Hope, Stillwater, Balesville, Swartswood, Middleville, Hainesburg, Colesville, Layton, Beemerville and Lafayette in New Jersey and Sunset Lake, and Bushkill Falls in Pennsylvania.

These developed areas will include a variety of land uses. The primary urban centers will include government centers, a high proportion of the region's service activities, a large hospital, a branch of the state university, and large industrial and commercial centers. The land uses in the secondary regional centers will depend upon demand and support for the facilities. The third-level settlements should have a uniquely rural character with sites for gift, craft, and antique shops, and quality restaurants. The density range of all of these areas is estimated to be over six persons per acre.

Recommended future development

The expansion of existing development is recommended for the regional centers. These areas have the capability to expand their population since they already have functioning utility systems servicing their population and an established economy. Other areas recommended for development are located by lakes, new highways, and scenic areas. The major resorts and recreation areas, such as Pocono Manor, Buck Hill Falls, Swartswood Lake, Camelback Mountain, High Point State Park, Stokes State Forest, and the DUGHERA, will also be major attractions for future development. These areas, as recommended for future development, are expected to have a density average of 4 to 6 persons per acre.

Rural.--Most of the land in the TIRES area will likely remain rural. This land will continue to be occupied by farms, forests, and scattered one-family dwellings. Although the land will not be

intensively used, it will always offer the opportunity for new subdivisions, resorts, and industries to be built. For the preservation of aesthetic and historic values in the region, care should be taken to insure that rural land remains rural.

Future land use considerations

In order to formulate realistic alternative systems for water supply and waste disposal, the Sketch Plan was adopted as the basis for future land use in the area. However, realizing that the Sketch Plan is only intended to be a generalized concept of how future land uses should be directed, it was updated and future land uses more specifically defined; its underlying premises and assumptions were accepted.

The considerations used to more specifically define the future land uses have already been discussed and included: a study of existing land use, proposed highway improvements, review of local land use studies, and population projections. With these as additional inputs and with the basic Sketch Plan assumptions maintained, future land use area boundaries were adjusted. The results are presented as Figure F-1.

Effectuation.--Prerequisite upon the implementation of any land use plan is the support of local citizens. Zoning and subdivision controls are necessary to prevent poor development but do little to encourage planned development. The electorate should encourage the public officials who are responsible for such plans to adopt them. The public officials in turn have the responsibility of keeping the local citizenry informed of the various stages of any plan. Close liaison is necessary for feedback between local public agencies and citizens. Coordination of all public agencies is necessary. The locations of roads, utilities, and public open space all help to influence private development. All financial and legal tools for the effectuation of the plans should be carefully explored, and regional cooperation with neighboring communities and the state and federal governments is essential for organized and meaningful implementation.

State and federal open space programs are a successful device for maintaining land in a rural and wooded state. The TIRES area is large enough to support more public forests and open space reserves. Selected areas in these open space preserves could be used for hunting, camping, hiking, or leased for resorts. The majority of this land should be left in a forested condition which would preserve the rural integrity of the National Recreation Area.

The design and location of new highways, be they local, state, or federal roads, are powerful determinants of land development. The large volume of tourist traffic is sure to generate strip commercial development along the highways; poorly designed and uncontrolled commercial establishments would completely devastate the rural impression that motorists want and should receive. New highways can also

serve the purpose of 'opening up' areas that are desirable for development, but that otherwise may remain inaccessible.

Urban renewal, currently in progress in Stroudsburg and recommended for Port Jervis, can be a tool for successfully revitalizing the larger urbanized areas within the Region. The deteriorating portions of these cities could be reconstructed and oriented toward recreation and vacation industries. Codes for building, fire, plumbing and sanitary regulations should all be strictly enforced to bring about optimum development. Joint authorities with members from both private and public organizations could finance and control all necessary utilities and facilities. Certain semi-public resorts and open space preserves could also be maintained through such an authority.

An area-wide authority (a composite of local and state governments and federal departments in the region) could plan and administer in a coherent, regionally oriented manner. This authority, a possible subdivision of the DRBC or a non-profit organization controlled by local municipalities (for example, TIRAC), could be given broad powers to tax and to condemn land to preserve open space. Various departments of state government might be encouraged to purchase or lease land in the TIRAC area and preserve it as open space.

Easements could be purchased, leased, or rented to provide scenic views and maintain utility lines. Scout and other resident camps should be encouraged as a way of keeping land in a predominantly wooded state.

All legal and financial tools for implementing good development and preserving open space should be utilized in order to guarantee the right of future generations to enjoy the DMGHRA and its surrounding area.



FIGURE F-1
DELAWARE RIVER BASIN COMMISSION

THIS PROJECT WAS SUPPORTED IN PART BY A
 DEMONSTRATION GRANT, NUMBER WPD-136,
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APPENDIX G
PROJECTED WATER-SUPPLY DEMANDS
AND
WASTEWATER FLOWS
FOR THE
DELAWARE WATER GAP
NATIONAL RECREATION AREA

G-1

WATER SUPPLY REQUIREMENTS AND SEWAGE FLOWS

FOR
DWGNRA PARK SITES

WATER SUPPLY REQUIREMENTS AND SEWAGE FLOW

FOR

DWGNRA PARK SITES

CODE NO.	NATL. PARK SERVICE NO.	STATE	SITE	PEAK POPULATION DISTRIBUTION							OTHER (Surplus People)	
				PICNIC		BEACHES	CAMP		BOATING			
				Sites	People	People	Sites	People	Boats	People		
			<u>BUSHKILL CREEK SECTION</u>		(4/Site)			(4/Site)				
	PA		Upland Davelopments	90	360	150	100	400	10			140
1	PA		Tocks Island	70	280	-	-	-	-			1,365
2	PA		Poxono	280	1,120	2,000	270	1,080	-			580
3	PA		Bushkill Creek	970	3,880	-	-	-	580			4,590
			<u>HILL FARM SECTION</u>									
	PA		Upland Developments	350	1,400	-	400	1,600	-			150
4	PA		Lehman	560	2,240	-	100	400	215			(-260)
5	PA		Egypt Mills	-	-	600	10	40	30			(-320)
6	PA		High Knob	10	40	-	-	-	15			20
			<u>DINGMANS CREEK SECTION</u>									
	PA		Upland Developments	750	3,000	-	600	2,400	-			(-80)
9	PA		Adams Creek	12	48	-	-	-	40			112
8	PA		Dingmans Creek	850	3,320	7,100	-	-	280			(-1,270)
7	PA		Hornbecks Creek	240	960	900	70	280	180			(-1,070)
			<u>GROUP CAMP SECTION</u>									
	PA		Upland Developments	-	-	-	-	-	-			1,200
10	PA		Dry Brook	-	-	80	20	80	15			(-80)
11	PA		Conashaugh Creek	-	-	80	20	80	15			(-80)
			<u>SILVER SPRING SECTION</u>									
	PA		Upland Developments	420	1,680	-	200	800	-			250
12	PA		Indian Point	30	120	-	50	200	80			135
			<u>MILFORD SECTION</u>									
14	PA		Tom Quick	450	1,800	5,000	-	-	-			1,025
15	NJ		Milleville	570	2,280	5,000	270	1,080	320			(-220)
13	PA		The Cliffs	550	2,200	10,000	-	-	-			(-1,525)
			<u>MINISINK SECTION</u>									
	NJ		Upland Developments	-	-	-	350	1,400	-			(-175)
16	NJ		Minisink	410	1,640	8,000	-	-	-			(-1,380)
17	NJ		Namanock	890	3,560	-	-	-	500			2,810
18	NJ		Sandyston	1,000	4,000	13,000	800	3,200	410			(-2,770)

Note: LUNCH FACIL.

15 Lunch Facilities

$\frac{142,000 \text{ Peo}}{15} = 9,500 \text{ Peo/Facil.}$

at 4 GPCD = 38,000 Gal/Day/Facil.

N. P. S. Peak Design Load People	G. P. C. D. WATER SUPPLY DEMANDS					OTHER SUPPLIES People At Avg. Rate 21.0 GPCD	LUNCH FACIL.	TOTAL G. P. D.
	SEWAGE	PICNIC	BATHING	CAMPS	BOATING			
	40 Gal/Car/Day	20 GPCD	10 GPCD	50 GPCD	10 GPBD			
	Gallons/Day	GPD	GPD	GPD	GPD			
1,050	42,000	7,200	1,500	20,000	100	2,940		31,740
1,645	65,800	5,600	-	-	-	25,665		34,265
4,780	191,200	22,400	20,000	34,000	-	12,180	38,000	146,580
11,470	338,800	77,000	-	-	5,800	96,390	38,000	217,790
3,150	126,000	28,000	-	20,000	-	3,150		111,150
2,580	95,200	44,800	-	20,000	2,150			66,950
520	12,800	-	6,000	2,000	300			8,300
60	2,400	800	-	-	150	420		1,270
5,320	212,800	60,000		120,000	-			180,000
160	6,400	960		-	400	2,352		3,712
3,150	366,000	66,400	71,000	-	2,800		38,000	178,200
1,070	42,800	19,200	9,000	14,000	1,800			44,000
1,200	48,000	-	-	-	-	25,200		25,200
80	3,200	-	800	4,000	150			4,950
60	3,200	-	800	4,000	150			4,950
2,730	109,200	33,600	-	40,000	-	5,250		78,850
455	18,200	2,400	-	10,000	800	2,835		16,035
5,775	231,000	36,000	50,000	-	-	21,525	38,000	145,525
6,140	325,600	45,600	50,000	34,000	3,200		38,000	190,800
10,675	427,000	44,000	100,000	-	-		38,000	182,000
1,225	49,000	-	-	70,000	-			70,000
8,260	330,400	32,800	80,000	-	-		38,000	150,800
6,370	254,800	71,200	-	-	5,000	59,010	38,000	173,210
17,430	697,200	80,000	130,000	160,000	4,100		38,000	412,100

M. P. S. Peak Design Load People	G. P. C. D. WATER SUPPLY DEMANDS					OTHER Surplus People At Avg. Rate	LUNCH FACIL.	TOTAL G. P. D.
	SEWAGE	PICNIC	BATHING	CAMPS	BOATING			
	40 Gal/Car/Day	20 GPCD	10 GPCD	50 GPCD	10 GPBD			
	Gallons/Day	GPD	GPD	GPD	GPD	21.0 GPCD		
4,585	183,400	31,600	-	80,000	-	29,505		141,105
60	2,400	8,400	-	-	200			8,600
105	4,200	4,800	-	-	300			5,100
1,540	61,600	14,400	3,700	52,200	2,300			72,600
240	9,600	-	-	-	200	5,040		5,240
1,365	54,600	10,400	10,000	-	100		38,000	58,500
5,635	225,400	40,000	9,000	184,000	100			233,100
2,205	88,200	10,400	-	50,000	800	14,585	38,000	115,585
6,510	260,400	20,800	64,000	-	-		38,000	122,600
1,365	62,600	5,600	2,100	23,200	-	12,831	38,000	81,731
240	9,600	-	2,000	18,200	-			20,200
7,962	318,480	26,400	43,000	116,000	-		38,000	225,400
1,260	50,400	3,600	11,000	58,000	600			73,200
35	1,400	-	-	-	100	735		835
5,325	213,000	16,000	-	70,000	-	65,625		151,625
2,915	116,600	33,600	-	-	-	25,935	38,000	97,535
141,522	5,660,880	904,560	665,900	1,303,400	31,600	413,973	570,000	4,889,633
	=5.66 MGD							

Note: LUNCH FACIL.
 15 Lunch Facilities
 $\frac{142,000 \text{ Peo}}{15} = 9,500 \text{ Peo/Facil.}$
 at 4 GPCD = 38,000 Gal/Day/Facil.

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APPENDIX H
DETAILED DESCRIPTIONS OF
ALTERNATIVE PLANS

WATER SUPPLY SYSTEMS

The existing water supply systems described in Appendix E will be capable of supplying only a small fraction of the future water demands in the TIRES area. The existing 32 public and private water supply systems presently serve a peak summer population of 66,000 with an average daily demand of 8.3 MGD. By 1980, the summer average daily water demand in the study area will exceed 41 MGD, and by the year 2020 almost a million people will require 139 million gallons a day.

This does not mean, however, that all existing facilities are obsolete. On the contrary, the four major systems in the study area, serving Stroudsburg, East Stroudsburg, Newton and Port Jervis all provide a high quality supply at a reasonable cost within their service areas. A limited increase in all four of these systems is possible, either by increasing surface water sources or supplemental ground water development.

The growth expected in the study area during the next 50 years necessitates a thorough evaluation of water supply potential and systems development on a regional scale, rather than consideration of minor modifications to each localized system. Several of the major communities in the TIRES area, faced with increasing water demands, have undertaken studies of their own systems. While the conclusions reached in each of these studies are valid for the respective community, only rarely do they take into consideration the water demand which will exist beyond the political boundaries of the community sponsoring the study.

The detailed study of individual water supply systems is beyond the scope of TIRES. Peak water supply demands have been presented on both sub-basin and minor civil subdivision bases, but the analysis performed herein places greater emphasis on water supply demand by watershed.

Ground water supply

As a general rule, the utilization of ground water for water supply is the most economical solution for relatively small localized systems. This is contingent on the quality and quantity of water in the available aquifers being satisfactory. Surface water use requires an impoundment structure, land area for the reservoir, treatment, and transmission. The various geological formations present in the TIRES area indicate excellent capacities as aquifers. Based on this information, the

first assumption made in the analysis of water supply was to make maximum utilization of ground water potential.

The initial step in the process of evaluating this ground water potential in the TIRES area included the study of over 3,000 existing wells in the Tri-State area. The work done by the New Jersey Department of Geology alone consisted of collecting and analyzing data for over 1,700 wells in the sections of Sussex and Warren Counties that fall within the TIRES study area. The data compiled on the existing wells in Pennsylvania and New York were much more fragmentary, and needed information was developed both by research of State records and field effort. Of the total 3,000 wells reviewed for the TIRES area, roughly half were located in the New Jersey section and the remaining portion divided between Pennsylvania and New York.

Over 80 percent of the data studied included wells meeting the domestic-use classification (normally less than 100 ft. deep with a supply of 6 gpm or less). It was felt that many of these small wells do not represent the potential of the aquifers in the study area. Therefore, only the major wells were included in the inventory of existing wells. A major well was defined as having a yield in excess of 30 gpm and a depth of over 100 ft. A total of 338 such wells have been located within the study area, and the number indicated on the drawing corresponds with the well inventory. Because of the limited areal extent of some aquifers, the wells are generally grouped in similar lithologic order.

Based on the tabulation of major wells, depth versus yield plots were made for each formational or rock type grouping in order to determine the maximum, minimum, and average depth and yield for the formations. In some cases where well yields appeared substantially lower than those in adjoining areas in the same formations, the locations were studied to determine whether the low yields were a function of well location or rock type. As can be seen in table H-1, the average depth in the rock wells are half or less than the optimum depth for availability of maximum water supply. This fact is important in estimating the average potential yield of the future wells discussed in the later section.

Having evaluated the existing ground water development, each sub-basin was next studied in terms of future water requirements for winter and summer usage in the years 1990 and 2020. These requirements were then expressed on the basis of mgd per square mile for each sub-basin area. These are shown on table H-2.

The ground water potential for each sub-drainage basin was evaluated in terms of recharge capacity versus future demands. A major concern of this portion of the work was the amount of recharge water necessary to maintain the various aquifers that comprise the ground water network. At the present time there has not been a quantitative

TABLE H-1
CHARACTERISTICS OF MAJOR WELLS

<u>Aquifer</u>	<u>Depth (feet)</u>			<u>Yield (gpm)</u>		<u>Number of Wells</u>
	<u>Maximum</u>	<u>Minimum</u>	<u>Average</u>	<u>Maximum</u>	<u>Average</u>	
Dc	1,800	40	204.8	200+	50.8	102
Dp	400	38	165.3	60	36.2	8
Dh	918	59	229.8	140	45.1	43
Dsl	350	50	129.2	150	50.1	36
Ds	315	54	132.5	100	48.6	15
Sb	316	47	149.3	450	62.6	16
SS	160	100	124.6	50	38.3	3
Om	500	50	204.9	220	55.2	45
OGc	521	40	168.2	815	103.2	33
PG	300	35	154.3	800	168.5	8
Unc	369	46	111.9	733	102.1	29

(Based on inventory of major wells which includes only those wells having yields of 30 gpm or more.)

Table H-2
TOCKS ISLAND REGION ENVIRONMENTAL STUDY
ESTIMATED GROUND-WATER YIELD
VERSUS
FUTURE TOTAL WATER DEMAND (MEDIUM PROJECTION)
(EXCLUSIVE OF DWGNRA)

Sub-Basin	Area (Sq. Miles)	Estimated Yield of Existing Large Wells January 1968 ¹		Future Water Demand (MGD)			
		(GPM)	(MGD)	1990		2020	
				Winter (5) 50%	Summer (6)	Winter (7) 70%	Summer (8)
PQ-1	55.5	1,097	1.58	0.85	1.70	2.73	3.90
PQ-2	28.8	365	0.53	0.30	0.60	1.57	2.20
PQ-3	25.4	265	0.38	0.45	0.90	1.57	2.20
PQ-4	26.9	770	1.11	0.95	1.90	3.50	5.00
PQ-5	28.3	105	0.15	0.70	1.40	1.26	1.80
NE-1	62.3	1,123	1.62	1.75	3.50	3.57	5.10
NE-2	11.4	830	1.20	0.30	0.60	0.84	1.20
FL-1	67.6	894	1.29	1.30	2.60	3.92	5.60
FL-2	14.8	287	0.41	0.05	0.10	0.14	0.20
BU-1	98.0	365	0.53	1.85	3.70	6.44	9.20
BU-2	34.0	170	0.24	0.40	0.80	1.54	2.20
BU-3	33.9	45	0.06	0.50	1.00	1.89	2.70
BR-1	65.8	730	1.05	2.15	4.30	6.92	9.90
BR-2	48.8	1,127	1.62	1.44	2.90	4.83	6.90
BR-3	47.9	1,715	2.47	1.72	3.44	6.16	8.79
BR-4	69.2	1,027	1.48	1.21	2.43	5.00	7.16
BR-5	28.9	325	0.47	2.15	4.30	6.70	9.60
BR-6	30.5	450	0.65	2.15	4.40	6.15	8.90
CH-1	26.4	550	0.79	0.50	1.00	1.61	2.30
KI-1	29.4	130	0.19	0.10	0.20	0.42	0.60
PA-1	37.0	125	0.18	1.00	2.00	2.87	4.10
PA-2	37.4	590	0.85	2.10	4.20	5.11	7.30
PA-3	25.8	309	0.44	1.65	3.30	4.27	6.10
PA-4	75.6	7,893	11.37	5.15	10.30	12.25	17.50
TOTAL	1,009.6			30.72	61.57	91.26	130.45

¹ Based on relatively short-term pumping tests and other yield data for existing wells. Yield estimates probably would be reduced if wells were pump-tested continuously for long periods during a prolonged drought.

² Maximum estimate represents ground-water recharge at 0.75 MGD/Sq. Mi., derived from Parker et al. (1964), multiplied by the area of the sub-basin.

³ In the absence of specific sub-basin recharge data, a factor of 20 percent of the generalized basin estimate, 0.75 MGD/Sq. Mi., is assumed for all sub-basins. This factor appears to be conservative, and need not be refined except for sub-basins for which the calculated ground-water yield is marginal or inadequate when compared with demand.

⁴ Column 14 minus Column 8, rounded to nearest tenth, except for BU-1, BR-4, BR-5, BR-6.

⁵ Indicated deficit may be reduced or eliminated by refinement of the projected 2020 demand, as shown in Column 8, or of the estimated design ground-water yield, as shown in Column 14. Any residual deficit possibly can be made up by transfer of ground water from adjoining sub-basins.

⁶ Total ground-water development is not feasible because of relative locations of demand centers and potential well fields.

⁷ These indicated deficits will probably have to be met by surface water supplies; total deficit approximately 15.20 MGD.

Demand per Square Mile (MGD/Sq. Mi.)				Estimates of Potential Ground-Water Yields, MGD		Ground-Water Surplus (+) or Deficit (-),
1990		2020		Maximum ² (13)	Design ³ (14)	2020, MGD ⁴ (15)
Winter (9)	Summer (10)	Winter (11)	Summer (12)			
0.015	0.030	0.049	0.070	41.6 ²	8.33	(+) 4.4
0.010	0.020	0.055	0.078	21.60	4.32	(+) 2.1
0.018	0.035	0.062	0.088	19.05	3.81	(+) 1.6
0.035	0.070	0.130	0.186	20.18	4.03	(-) 1.0 ⁵
0.025	0.050	0.044	0.064	21.23	4.25	(+) 2.4
0.028	0.056	0.057	0.082	46.73	9.35	(+) 4.2
0.026	0.053	0.074	0.105	8.55	1.71	(+) 0.5
0.019	0.039	0.058	0.083	50.70	10.14	(+) 4.5
0.003	0.007	0.010	0.014	11.10	2.22	(+) 2.0
0.019	0.038	0.066	0.094	73.50	14.70 ⁶	(-) 4.6 ⁷
0.012	0.023	0.045	0.065	25.50	5.10	(+) 2.9
0.015	0.030	0.056	0.080	25.43	5.08	(+) 2.4
0.033	0.065	0.105	0.150	49.35	9.87	0.0
0.030	0.059	0.099	0.141	36.60	7.32	(+) 0.4
0.036	0.072	0.130	0.180	35.93	7.19	(+) 1.6 ⁵
0.018	0.035	0.070	0.103	51.90	10.38 ⁶	0.0
0.074	0.149	0.232	0.331	21.68	5.77	(-) 4.0 ⁷
0.070	0.141	0.202	0.288	22.85	4.57 ⁶	(-) 6.6 ⁷
0.019	0.038	0.061	0.087	19.80	3.96	(+) 1.7
0.003	0.007	0.014	0.020	22.05	4.41	(+) 3.8
0.027	0.054	0.078	0.111	27.75	5.54	(+) 1.4
0.056	0.112	0.137	0.195	28.05	5.61	(-) 1.7 ⁵
0.064	0.128	0.165	0.236	19.35	3.87	(-) 2.2
0.068	0.136	0.162	0.231	56.70	11.34	(-) 6.2 ⁵

recharge study in the Upper Delaware River Basin. The closest comparative study, cited by Parker et al. (1964), was made in the Pomperaug Basin of Connecticut, where the ground water recharge potential was calculated at 0.75 mgd per square mile. There are definite similarities between the Pomperaug Basin and the TIRES area. Both areas were glaciated and both areas have a somewhat similar rock type with similar structural deformation causing shears and faults in the rock. Therefore in order to preserve existing hydrologic expression, and prevent substantial drawdown of the water table, 20 percent of the 0.75 mgd per square mile figure was estimated as the usable withdrawal of ground water per square mile for the TIRES area. Table H-2 shows the summary by sub-basin of potential ground water yields, with the usable yield being compared with the peak summer demand for each sub-basin.

The preliminary comparison of these figures indicated that the future water requirements from all but eight of the sub-basins might be satisfied by utilizing only ground water sources. In the eight sub-basins where the future demands will not be entirely satisfied by ground water, various alternatives were considered. Special hydrologic conditions in five of the sub-basins indicate that additional quantities of water can be withdrawn from the aquifers without significantly lowering the water table or reducing streamflow. In one case, (PO-4), very significant deposits of highly permeable sand and gravel exist. In another sub-basin, (PA-4), highly soluble limestones are found, which create high recharge zones, due to solution channels and secondary porosity.

Each sub-basin was correlated with the geological formations to determine which major formations were located within it. For each respective formation, the average potential yield of major wells was estimated, under the assumption that each of these major wells would be properly located and drilled to optimum depth. These average yield values are shown in Table H-3 by formation.

Next, each sub-basin was examined in detail, and potential well fields were generally located. These well field locations were then checked against the pattern of future land use, and supply versus future demand balanced by development stage. For water supply planning, stage 1 includes the demand increase from 1970 thru 1990, and stage 2, 1990 thru the end of the study period (2020). Where ground water will be both adequate and convenient, the future water demand in mgd for each sub-basin is assumed to be met by the required number of wells in the respective aquifers present in the sub-basin area. This tabulation, for the two study periods in question, is available as open file data from DRBC. For example, in sub-basin PO-1 covering an area of over 55 square miles, a future summer population of over 12,000 by the year 1990 will create a water demand of some 1.7 million gallons a day. This demand could be met by drilling 10 large wells in the Catskill formation in ten different well fields, and one well in the Hamilton formation. In the second stage of the development, seven more wells

TABLE H-3
AVERAGE POTENTIAL WELL YIELDS
OF
GEOLOGIC FORMATIONS
IN THE TOCKS ISLAND REGION

<u>Symbol</u>	<u>Geologic Formation</u>	<u>Potential Yield, gpm</u>
Unc	Valley bottom glacial deposits	350+
Dc	Catskill	200
Dp	Portage	100
Dh	Hamilton - Mahantango only	100
Dsl	Onondaga	150, 75-250
	Esopus	75
	Oriskany	100-250
DS	Holderberg	100
Sb	Bloomsburg	200
Ss	Shawungunk	50
Om	Martinsburg	100
OGc	Carbonates (except Jacksonburg)	300
PG	Gneisses	75

could be drilled in the Catskill formation and two more in the Hamilton formation. This will give an estimated total potential yield of some 5.3 million gallons a day by the year 2020, more than adequate for the summer water demand of 3.9 mgd created by the 26,000 people in the area. In this particular sub-basin, the well fields are distributed throughout the area and are near the expected future development areas. However, because the population will be fairly well spread throughout the area, extensive distribution lines will be required. In addition, some of the fields are in remote and undeveloped areas and will require power transmission to the fields.

This same type of detailed analysis was performed for each sub-basin area. The wells required during the first stage (1970 to 1990), will be constructed throughout the period and will not be built at any one given time. Generalized well field locations are shown in lieu of specific well sites. Any field could be relocated if future land use development differs from the projected pattern, or if it is desirable to provide a more uniform distribution of ground water withdrawal in the latter portion of the first development period. The same thing is true of ground water development in the second development phase.

As each sub-basin was analyzed, the estimated usable ground water potential shown in Table H-2 was evaluated to determine whether or not it represented the developable ground water potential for the sub-basin. In some cases this value was found to be misleading. In one sub-basin, BR-5, either the transfer of surplus ground water from adjacent basins or surface water development will be necessary. In two other sub-basins, BU-1 and BR-6, potential well fields are too remote from future populations, and additional sources will be required.

The water supply requirements within the DWGNRA are relatively small compared with those outside the Recreation Area. As the water requirements for the various activity areas were studied, it became apparent that the required water supply for virtually all these areas could be met by the construction of two domestic type wells per area. At major park sites where larger yields will be required, the geology was examined to determine the feasibility of more extensive ground water development. In every case there appeared to be sufficient capability to supply the entire requirement from ground water sources. Many park sites, because of their close proximity to each other, could logically be supplied from a common source, for economy of installation and operation. It will also be possible in some areas, such as the park sites adjacent to Milford Borough or around Bushkill Inlet, to develop water supply systems in conjunction with community systems.

Surface water development

For those areas where the estimates of potential ground water yield indicate that it will not be adequate for future summer demand, a study of supplemental water supply has been made. The amount of the

deficit in each sub-basin was estimated, and the probable locations of major future population concentrations in each sub-basin were examined. While the analysis varied with each deficit area, three basic alternatives were considered.

- a. The possibility of developing well fields in adjacent sub-drainage basins with a surplus of ground water potential, and transmitting it into the deficit basin, was considered. Here the major cost of water supply development would be for transmission between sub-basins rather than for well-field development.
- b. Development of surface impoundments within the sub-drainage basin area was considered. Potential sites for dam structures were taken from the North Atlantic Region Watershed Inventory and watershed work plans developed by the Soil Conservation Service. Many of the potential dam sites considered by the SCS are primarily for the purpose of flood control, and had to be evaluated quantitatively as to their feasibility for water supply impoundments. Only a very limited number of the sites located within the study area were considered for surface water development, and each one of these would require further study before it was finally selected as a multi-purpose reservoir site.
- c. A major portion of the storage volume in the Tocks Island Reservoir has been allocated for future water supply. As many of the major growth areas lie within a few miles of the reservoir, consideration was given to withdrawal, treatment, and transmission from the reservoir to the populated areas.

Since each sub-basin was analyzed separately, the comparison between alternatives will be described by each sub-basin.

BU-1 (Bushkill-1).--For this sub-basin, the estimated additional demand is 1.8 mgd by the year 1990 and 4.6 mgd by the year 2020. While the initial evaluation of total ground water potential for the sub-basin indicated some 14.7 mgd, a study of the sub-basin itself indicated that the potential well fields were too far removed from the future population centers. Most of the upper part of this sub-basin, which is underlain by the high yielding Catskill formation, is expected to be very sparsely populated through our study period. Much of the land in this area is State game land or private hunting and fishing clubs, and will probably remain so for many years. Most of the growth anticipated within the sub-basin will occur in the valley along the route near Bushkill Inlet, adjacent to the reservoir and the National Recreation Area. Formations which underlie this portion of the sub-basin are much poorer aquifers.

To meet the deficit water supply demand, two alternatives were considered. Alternative 1 was based on the development of well fields in the upper sub-basin (State game lands) and transmission down the valley of Big Bushkill Creek to the junction of U. S. 209 near Bushkill Inlet. Alternative 2 was based on withdrawal from Tocks Island Reservoir at Bushkill Inlet, pumping to an elevated raw water storage facility in the valley (elevation 600), and treatment. Other distribution and storage costs were felt to be equal. The following table H-4 is a cost comparison between the two alternatives.

The supplementary water supply required, on which the cost comparison is based, is equal to approximately 50 percent of the total sub-basin demand for the two study periods. This assumes that the population creating this portion of the demand will be readily available to a valley distribution system. It neglects the effect of Well Field No. 8 in the unconsolidated deposits near Bushkill Inlet, assuming that this will be utilized by park facilities in the area. While a combination system, utilizing both surface water withdrawal from the reservoir and limited ground water development, is possible, this assumption had to be made to give a quantitative cost comparison. This comparison indicates that the development and utilization of surface water supply from the reservoir is cheaper both in terms of capital cost and annual cost, even including the very high operation and maintenance cost associated with a treatment plant.

It can be seen that the major cost element in the construction and development of well fields in the upper sub-basin is the cost of transmission, and the annual cost is greater in Stage 1, based on the assumption that the required transmission lines would be constructed during the first phase of construction. The utilization of well fields closer to the valley, or the possible stage development of the transmission facilities might greatly reduce both the capital cost and the annual cost for well field development. However, it is felt that the available ground water resources in the upper portion of the sub-basin immediately adjacent to the Route 209 valley will be utilized by residents in those areas, and the Route 209 valley residents must choose between long range transmission of ground water sources, or treatment and transmission of reservoir water.

Brodhead Creek-5 (BR-5).--This sub-basin, covering an area of a little less than 29 square miles, will be the most densely populated sub-basin within the entire study area. By the year 1990, the summer population is expected to reach over 32,000 people with the water demand in excess of 4.3 million gallons per day. By the year 2020, this population will double to 64,000 people and the demand will increase to 9.6 million gallons per day. The sub-basin is comprised of the most densely populated areas of East Stroudsburg Borough, Smithfield Township, Stroud Township, and small parts of Middle Smithfield Township

TABLE H-4

BUSHKILL-1 (BU-1)

COST ANALYSIS
ALTERNATIVE ONE--WELL FIELDS AND TRANSMISSION

Item	Units	No. of Units	Capital Cost, thousands of dollars		Annual Cost, dollars
			Per Unit	Total	
Stage 1--1970-1990					
Well Construction	Wells	7	30	210	= \$169,478.00
Power	Miles	8	65	520	= 8,400.00
Water Transmission	Miles	17	111	1,887	= 95,000.00
Storage, Ground Tanks	mgd	1.8	100	180	= 15,000.00
Pumping (Over Ridgeline)	HP	1.5	--	110	
Sub-Total				2,937	\$227,878.00
Stage 2--1990-2020					
Well Construction	Wells	10	30	300	= \$42,200.00
Storage, Additional	mgd	2.8	100	280	= 12,000.00
Pumping, Additional Station	HP	210	--	145	= 50,000.00
Sub-Total				725	\$124,000.00
TOTAL				3,632	\$352,078.00 by 1991

ALTERNATIVE TWO--RESERVOIR WITHDRAWAL AND TREATMENT

Stage 1--1970-1990					
Intake Structure	--	1	L.S.	50	
Pump Station (500' TDH)	HP	1.5	--	110	Amortization 0 and M = 1.18 mgd
Transmission to					Chemicals 500.00/Mo. x 12)
Raw Water Reservoir	Ft.	8,000	0.021	168	Malts 900.00/Mo. x 12)
Raw Water Reservoir	Cu. Yd.	24,000	--	87	Labor and OP 55,000.00/Yr. +)
Treatment Plant	mgd	1.8	410	738	Power (Pump Only) 5,000.00/Yr.)
Sub-Total				1,155	<u>15,000.00</u>
					<u>\$136,100.00</u>
Stage 2--1990-2020					
Pump Station No. 2	HP	210	--	145	Amortization 0 and M at 4.6 mgd
Transmission - 2nd F.M.	Ft.	8,000	0.021	168	104,000.00/Yr. at 4.6 mgd
Treatment					Power (Pump Only)
Increase to 4.6 mgd	mgd	2.8	550	480	104,000 - 56,800
Sub-Total				1,295	<u>47,200.00 Incr.</u>
TOTAL				2,445	<u>20,000.00</u>
					<u>\$142,700.00</u>
					<u>\$278,000.00 by 1991</u>

and Stroudsburg Borough. Upper portions of the sub-basin are underlined by the Catskill Formation, but most of the more densely populated regions will occur in the suburban areas surrounding the two Stroudsburgs, which is underlain by the Hamilton Formation. These formations will be adequate to meet the demand through the first phase of development and a portion of the second, but that an auxiliary water supply source must be developed during the second phase.

The capacity of the auxiliary supply required is estimated at 4 million gallons per day. Four possibilities were considered to meet this additional supply.

- a. Construction of a small reservoir on Michael Creek in Price and Middle Smithfield Townships.
- b. Increased diversion from Brodhead Creek by the Stroudsburg system.
- c. Diversion of water from the Tocks Island Reservoir via the Route 209 Valley Transmission Line.
- d. Transmission of water from Upper Basin (Price Township), using surplus ground water potential.

The small reservoir site on Michael Creek would not be satisfactory as a major surface water impoundment site. At present, Michael Creek is diverted to feed into the East Stroudsburg Reservoir located on Sambo Creek.

The second alternative, increasing the diversion from Brodhead Creek into the Stroudsburg system to supply future Stroudsburg and suburban-area requirements, might satisfy a portion of the future demand, even as much as two million gallons per day. However, this partial answer would apply to only the western portion of sub-basin BR-5, and would not satisfy the total demand without a new impoundment structure, treatment plant, and other major distribution components.

The third possibility considered increasing the treatment plant capacity of the facilities proposed in sub-basin BU-1 from 4.6 million gallons per day by 2020 to 8.6 million gallons per day. Table H-5 outlines the cost estimate of this concept, including expansion of the intake structure, transmission of raw water to the plant reservoir, increase in plant capacity, and transmission down the valley of Route 209 to the service area of sub-basin BR-5. The cost comparison is presented both in terms of capital cost and annual cost.

The fourth possibility, tapping the ground water resources in the upper sub-basin and transmission down the valley of the Brodhead into sub-basin BR-5 was also considered. Under this plan, two well fields in sub-basin BU-1 and two well fields in sub-basin BR-4, which

TABLE H-5

COST COMPARISON OF
SUPPLEMENTARY WATER SUPPLY

CONSTRUCTION COST - ALTERNATIVE C

Expansion

Pump Station	\$ 145,000.00
Transmission	40,000.00
Plant	<u>1,150,000.00</u>
Sub-Total	\$ 1,335,000.00

Transmission Down the Valley

Pipeline	\$ 1,110,000.00
Pump Stations	<u>450,000.00</u>
Sub-Total	\$ 1,560,000.00

TOTAL	<u><u>\$ 2,895,000.00</u></u>
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CONSTRUCTION COST - ALTERNATIVE D

2 Wells	\$ 420,000.00
Power Supply	390,000.00
Transmission	<u>2,330,000.00</u>
TOTAL	<u><u>\$ 3,140,000.00</u></u>

are not required for the water demand of those sub-basins, would be utilized. Major transmission lines down the Brodhead Valley would be the most expensive component in developing this water supply source. The cost estimate for this alternative is also shown in table H-5.

The capital costs of the two alternatives are fairly close. The annual costs shown in Table H-6 indicate that the development of the remote well fields in the adjacent sub-basins and transmission would be slightly less. However, in light of the analysis of sub-basin BR-6, the use of water from the Tocks Island Reservoir will be slightly more favorable a concept, and the cost will be reduced as the expense of transmission facilities is shared between BR-6 and BR-5.

Brodhead Creek-6 (BR-6).--This sub-basin will be the second most densely populated region within the TIRES area by the end of the study period, with an average density of some 3.36 persons per acre. The population is expected to exceed 31,500 by the summer period of 1990, creating a water demand of over 4.4 million gallons per day. This population will almost double by the year 2020 to some 58,900 people, with a total demand of 8.9 million gallons per day. The sub-basin includes over 30 percent of the area of East Stroudsburg Borough, approximately 45 percent of Middle Smithfield Township, 37 percent of Smithfield Township, and a small portion of Stroudsburg Borough. More important, it includes the Brodhead Creek Valley at its confluence with the Delaware River, and the Marshalls Creek - U. S. 209 valley as far as Echo Lake.

In the preliminary analysis, it was proposed that a major portion of the future water demand be met by the development of 13 large wells in the Catskill Formation portion of the basin. This area represents only 25 percent of the total sub-basin. Development at this intensity would mean an average withdrawal of some 457,000 gallons per square mile per day, which is substantially in excess of the assumed (or estimated) safe limit of 150,000 gallons per square mile per day.

Thus, the initial estimate of ground water potential was felt to be an overestimate for this sub-basin. Geological correlation within the sub-basin indicated a potential development of five major wells at 200 gallons per minute in the Catskill Formation in the upper portion of the sub-basin. Population development will occur here, but most of the intense development will be in the valley along Highway U. S. 209 and in the lower sub-basin surrounding East Stroudsburg. The formation present throughout most of this area is the Hamilton, with a potential for only comparatively low-yield wells (100 gallons per minute or less). Geologic analysis indicates only six wells at 100 gallons per minute can be developed in this area. This yields a total sub-basin ground water withdrawal of 600 gallons per minute or 0.85 million gallons per day. This is an average sub-basin ground water yield of 75,000 gallons per day per square mile.

TABLE H-6

ANNUAL COST COMPARISON OF ALTERNATIVES C AND D

Alternative C		Alternative D	
Increase withdrawal from Tocks Island Reservoir, Treatment, and Transmission to BR-5 during stage 2		Develop remote well fields in BR-4 and BU-1, transmission to BR-5 during stage 2	
Capital Cost 2,895 Mill		Capital Cost 3,140 Mill	
Amortization (5% - 40 Yr. CRF = 0.0583)		(0.0583) (3,140,000.00)	
(0.0583) (2,895,000.00)		0 and M (4% of Wells)	
		(0.04) (420,000.00)	
0 and M		Power	
8.6 mgd Cap.		14 Wells at 5,000.00/Well/Yr.	
Chem. 2,300.00/md) 4,300.00/mi. = \$ 51,600.00/Yr.		Selected	
Filter 2,000.00/md)			
Labor and OP 85,000 - 10,000 = 95,000.00			
4.6 mgd Cap. = \$104,000.00/Yr.			
Increased 0 and M			
Transmission / Power and Maint.)			
\$ at 30,000.00			
Estm. 500 HP Each			
Total Annual Cost			

This limit is substantially lower than the average ground water recharge potential used in other parts in the TIRES area, but is felt to be a more realistic estimate for this sub-basin.

The deficit for sub-basin BR-6 is as follows:

<u>Year</u>	<u>Water Demand (mgd)</u>		<u>Deficit (mgd)</u>	
	<u>Summer</u>	<u>Winter</u>	<u>Summer</u>	<u>Winter</u>
1990	4.4	2.15	2.1	0
2020	8.9	7.10	6.6	4.8

Three alternatives were considered to meet this deficit:

- a. Tapping additional ground water resources in undeveloped portions of other basins and transport this high quality water into the deficit area of BR-6. This alternative appeared to be slightly more economical for the adjacent basin BR-5.
- b. Increasing the capacity of withdrawal and treatment facilities from Bushkill Inlet at Tocks Island Reservoir which would be used to supplement the supply in the adjacent sub-basin, BU-1. This would require transmission down U. S. 209 and Marshalls Creek to the growth areas, a method which proved slightly more expensive in the analysis of sub-basin BR-5.
- c. Creating two reservoirs within sub-basin BR-6 for water supply only, at the SCS sites, with capacity limited to the deficit, and with one or both of the impoundments expanded during phase 2.

A cost analysis of these three alternatives indicated that the development of the combined surface water withdrawal and treatment facility in conjunction with the adjacent sub-basin BU-1 is the most economical solution to the water supply demands in basin BR-6. With the cost of transmission of Tocks Island Reservoir water into this sub-basin area being justified by this demand, the incremental cost to distribute water even further into the adjacent sub-basin BR-5 becomes substantially less than that estimated in the previous analysis for BR-5. The following section will describe how a regional water supply treatment and distribution system can serve all three of these deficit sub-basins.

Route 209 valley water supply system.--The existing East Stroudsburg Water Supply System is assumed to be adequate to meet the needs of the Borough thru the year 1990. However, the growth in the adjacent townships will far exceed the capacity of this surface water supply. By that time, the total water demand in the surrounding

drainage basins of BR-5, BR-6, and BU-1 will exceed 12.4 MGD. Most of this demand will occur in a fairly limited area from East Stroudsburg to Bushkill inlet, and will not be uniformly distributed throughout the basins.

Therefore, the total estimated ground water resources cannot be developed, and must be limited to approximately 7 to 8 MGD. This ground water usage may be even less if the population density is greater than expected in the poorer geologic formations, such as the Hamilton. With an estimated reliable yield of 1.5 MGD from the East Stroudsburg system, a deficit of approximately 3.9 MGD will exist by 1990, located primarily in Smithfield and Middle Smithfield Townships and throughout the valley surrounding U.S. Route 209 from East Stroudsburg northeast to the National Park limits.

To meet this future deficit, a central water supply system is proposed. This water supply distribution system is a result of the analysis of deficit water supply in sub-basins BU-1, BR-5, and BR-6. It would utilize storage volume in the Tocks Island Reservoir allocated to water supply, and would withdraw, treat, and distribute this water in the valley from Bushkill Inlet to East Stroudsburg.

The following summarizes the water supply deficits by sub-basin and indicates the location of the population creating this deficit.

<u>Sub-Basin</u>	<u>Water Deficit (mgd)</u>	
	<u>By 1990</u>	<u>By 2020</u>
BU-1	1.8	4.6
BR-5	0	4.0
BR-6	<u>2.1</u>	<u>6.6</u>
	3.9	15.2
<u>Estimated Service Population¹</u>	<u>1990</u>	<u>2020</u>
Middle Smithfield Township	16,500	40,700
Smithfield Township	12,300	34,700
Stroud Township	0	5,000
East Stroudsburg Borough	<u>0</u>	<u>21,000</u>
	28,800	101,400

¹ Based on withdrawal from Bushkill Inlet and distribution to Middle Smithfield and Smithfield Townships in stage 1; extension to East Stroudsburg Borough and Stroud Township in stage 2.

The development of a surface supply is felt to be essential to meet the future demands within this valley. The withdrawal of some four mgd from the reservoir would have virtually no effect on the reservoir itself, since it represents only some 12 acre-feet per day from an impoundment that has an average summer storage capacity of 500,000 acre feet. In the event that some of the anticipated well fields located in sub-basins BR-1 and BR-2 do not produce the yield expected, the withdrawal and treatment capacity required by this plant might well exceed the 15,000,000 gallons per day demand estimated by 2020. However, the high cost of transmission decreases the advantage of surface water utilization beyond a 10 to 12 mile range of this impoundment.

Since the underlying principle in the development of all water supply systems is to provide maximum utilization of water resources, both surface and ground water, the final system serving the Stroudsburg and the surrounding townships should be a network of transmission lines supplied by the available well fields and the proposed Route 209 valley water supply treatment plant.

LIQUID WASTE DISPOSAL SYSTEMS

Brief descriptions of alternatives

The five alternative wastewater collection and treatment systems studied are shown on Figures 1 thru 5 and may be described briefly as follows.

Alternative I - Multiple Small Systems.--This alternative includes 116 individual water pollution control plants, ranging in size from 0.02 to 5.0 mgd. These would serve each population concentration within the study area as it developed, and would minimize the extent of collection systems. By the end of our study period in the year 2020, approximately 76 percent of the peak summer population would be included in the service areas.

Alternative II - Limited Sub-Regional Systems.--This alternative includes 52 treatment plants, ranging in size from 0.02 to 24.0 mgd. It is generally a combination of Alternatives I and III and includes eight limited sub-regional systems, with 44 smaller treatment plants serving less concentrated development areas. By the year 2020, approximately 84 percent of the peak summer population would be served.

Alternative III - Sub-Regional Systems.--This alternative services six sub-regional areas with six plants; ultimate treatment plant capacities range from 3.6 to 28.0 mgd. By 2020, nearly 88 percent of the peak summer population within the study area would be served. (In addition to the six sub-regional plants, there are 15 very minor facilities serving isolated areas. These 15 facilities only serve about one percent of the service population and so are not elaborated upon herein.)

Alternative IV - Regional System, Evolved.--This is basically Alternative III developed through the year 2000, with total regionalization, by interconnection of collection systems and centralized treatment occurring during the final development phase.

Alternative V - Regional System.--This alternative provides all treatment at one plant located below the reservoir. Flows to this plant would include the wastewaters from the Paulins Kill drainage basin. Alternate plant sites at the mouth of the Brodhead Creek or the Paulins Kill, as shown on Figure 5 would require pumping through the Delaware Water Gap. An ultimate plant capacity of approximately 90 mgd would provide treatment for over 91 percent of the peak summer population by the year 2020. (In addition to the one regional plant, there are 15 very minor facilities serving isolated areas. These 15 facilities only serve about one percent of the service population and so are not elaborated upon herein.)

Alternative VI.--For comparative purposes, this Alternative was developed by combining I and III. Alternative I would be constructed during the first stage and then abandoned during the

second stage. Alternative III would be built during the second and third stages.

The development of the systems under each alternative has been staged to correspond with population growth in the study area. None of the four alternatives could or should be built at one time, but rather would grow to meet the demand as it occurred. Since population growth will not occur at a constant rate over the 50 year study period, three periods of systems development and construction have been considered.

Phase 1: 1970-1980 (Beginning of major growth period)

Phase 2: 1980-2000 (Period of maximum growth rate)

Phase 3: 2000-2020 (Period of relative increase in permanent residential population)

The recommended staging of each alternative has also been shown on Figures 1 through 5.

Alternative 1 - Multiple Small Systems

Description of Alternative 1.--The rationale behind Alternative 1 is that a wastewater collection and treatment system is built to serve each individual pocket of development and population growth as the need occurs.

There are six small communities which have an immediate need for wastewater collection and treatment systems. These communities are expected to have a total peak summer population of 23,000 by the year 1975. These communities are the boroughs of Matamoras, Milford, and Mt. Pocono in Pennsylvania, the borough of Branchville in New Jersey, Barrett Township in Pennsylvania, and the northern section of Stroud Township bordering on the communities of Stroudsburg and East Stroudsburg.

Within Barrett Township, the small community of Buck Hill Falls is already served by a small package plant, and the adjacent communities of Cresco, Mountain Home and Canadensis, are in urgent need of collection and treatment facilities. This township system, if developed, should include the service area of Buck Hill Falls when the small package plant reached its design life.

The suburban communities surrounding the Stroudsburgs have been experiencing extensive urbanization within the last few years, and this growth phase will continue and accelerate within the near future. The two existing public systems are not capable of handling this additional burden; therefore, under Alternative 1, an additional plant should be built early in Phase 1 to serve the northern suburban areas.

Within the latter half of Phase 1, the study area will begin to feel the first major impact resulting from the development of the DWGNRA. With the opening of the Recreation Area scheduled for the late 1970's, and ultimate development anticipated by 1985, required service facilities must be constructed prior to 1980. Under Alternative 1, facilities serving the Recreation Area will not service residents outside the Recreation Area limits. This results in the construction of 16 "zone"⁽¹⁾ systems and 33 individual facility plants serving the Recreation Area. These 49 treatment facilities will serve the 10,500,000 annual visitors, most of whom will utilize the facilities during the 3 to 4 month summer period. With a maximum daily summer occupancy of approximately 141,500 people, the wastewater collection and treatment facilities provided must have a total capacity of 5.7 mgd.

The average daily demand on each of the 49 treatment facilities would be less than design capacity, and the period of use would probably not exceed 4 months per year. This kind of operation requires a large staff of skilled personnel during the summer periods.

(1) A Zone System in Alternative 1 is defined as one that serves several areas as opposed to a single service area.

Outside of the DWGNRA, a number of smaller communities will be experiencing increased development during the years 1975 to 1980. This growth will create the need for construction of some 13 zone plants in the balance of the study area outside the DWGNRA during the latter half of construction Phase 1. The 13 plants will have an aggregate service population of 118,000 by 1985, and should increase in capacity by the year 2020 to serve over 255,000 people. Several of these plants have significant capacity; the largest is located near the community of Marshall's Creek in Smithfield Township and will have an ultimate design capacity of 5 mgd.

During the 35 year growth period from 1985 to 2020, the 13 systems will more than double their capacity. They represent those portions of the study area which will feel the first real impact of accelerated growth, and which will become the future population centers within the study area.

The four existing public systems serving Stroudsburg, East Stroudsburg, Newton, and Port Jervis would require no modification during Phase 1.

During Phase 2, from the years 1980 to 2000, the study area will be undergoing its period of maximum rate of growth. Most of the larger water pollution control plants required to meet this demand will have already been constructed during Phase 1. Therefore, during Phase 2, it will be necessary to expand the capacities of the 24 existing treatment plants outside the DWGNRA and develop a number of new facilities. New development includes 16 zone systems and 11 small systems and plants. During this phase, it will be necessary to replace the existing Stroudsburg plant, provide for major expansion of the existing East Stroudsburg plant and system, replace the Newton plant, and expand the existing Port Jervis plant.

The 16 "zone" plants to be constructed during construction of Phase 2 will be relatively small in size, ranging in ultimate capacity from 0.2 to 2.5 mgd. The ultimate service population of the 16 plants will be approximately 167,000 people. The 11 small systems will have an aggregate treatment capacity to serve over 29,000 people by the year 2020. The 4 existing treatment plants which will be expanded or replaced during this construction phase will represent an aggregate service population of over 95,000 by the year 2020.

During Phase 3, an additional 4 zone systems and 12 small systems will have to be built. In terms of population served, they represent a total of 40,000 people.

Table H-7 presents a summary of relevant data for Alternative 1.

TABLE H-7

WATER POLLUTION CONTROL PLANTS
DESIGN POPULATIONS AND PLANT CAPACITIES
ALTERNATIVE I

Construction Phase One (1970-1980)				Design Capacity by Construction Period (MGD)		
Plant No.	Community or Area Served	Peak Summer Service Population 1975	Population 2000	1970-1980	1980-2000	2000-2020
One-A Immediate Needs (1970-1975)						
1	Matamoras Boro	3,600	6,400	0.5	0.7	0.9
2	Milford Boro	2,400	4,500	0.4	0.5	0.8
3	Mt. Pocono Boro	2,000	4,000	0.3	0.4	0.7
4	Barrett Twp.	3,300	20,000	1.2	2.0	3.0
5	North Stroud Twp.	5,000	10,000	0.7	1.0	1.5
6	Branchville Boro	1,700	6,000	0.3	.5	.9
Sub-Totals:		23,600	50,700			
One-B (1975-1980)						
7	"Mill Brook"					
8	Montague	3,000	5,500	0.3	0.6	0.8
9	"Little Flat Brook"	6,000	11,000	0.6	1.1	1.5
10	Marshall's Creek	8,000	13,000	0.8	1.3	1.8
11	Paradise Twp.	20,000	40,000	2.0	4.0	5.0
12	"Lower Pocono Creek"	14,000	30,000	1.4	3.0	4.3
13	"Culvers Lake"	6,000	11,000	0.6	1.1	1.5
14	Balesville	12,000	16,000	1.2	1.6	2.0
15	"Paulins Kill Lake"	5,000	6,000	0.5	0.6	0.8
16	"Swartswood Lake"	12,000	14,000	1.2	1.4	1.6
17	Blairstown #1	12,000	17,000	1.2	1.7	2.0
18	Hainesburg	16,000	25,000	1.6	2.5	3.0
19	Columbia	2,000	5,000	0.2	0.5	0.6
Sub-Totals:		2,000	5,000	0.2	0.5	0.6
Sub-Totals:		118,000	198,500			
Delaware Water Gap National Recreation Area						
20-35	16 "Zone" Plants			5.7	5.7	5.7
36-68	plus 33 Individual Plants					
		141,500	141,500			

TABLE H-7
(continued)

WATER POLLUTION CONTROL PLANTS
DESIGN POPULATIONS AND PLANT CAPACITIES
ALTERNATIVE I

Construction Phase Two (1980-2000)				Design Capacity by Construction Period (MGD)		
Plant No.	Community or Area Served	Peak Summer Service Population	1975	1985	1990-2000	2000-2020
"Zone" Plants						
69	"Neversink Valley"	6,000	8,500	9,000	0.9	0.9
70	"Delaware Valley"	4,000	5,000	7,000	0.7	0.7
71 #1	"Hogaupe Valley"	2,000	2,500	4,000	0.5	0.4
72	"Saw Kill"	1,500	3,000	5,000	0.3	0.5
73	"Raymond Kill"	3,000	12,000	20,000	1.2	2.0
74	"Conashaugh"	200	1,000	2,000	0.1	0.2
75	"Dingmans Creek"	5,000	8,000	10,000	0.8	1.0
76	"Hornbecks Creek"	3,000	5,000	7,000	0.5	0.7
77	"Toms Creek"	3,000	4,000	8,000	0.4	0.8
78	"Little Bushkill Creek"	5,000	7,000	10,000	0.7	1.0
79	"Upper Pocono Creek"	8,000	18,000	25,000	1.8	2.5
80	Hamilton Twp.	4,000	7,000	9,000	0.7	0.9
81	Lafayette Twp.	2,500	5,000	7,500	0.5	0.8
82	Stillwater Twp. #1	5,000	15,000	25,000	1.5	2.5
83	Blairtown #2	2,000	6,000	10,000	0.6	1.0
84	Minisink Hills	4,000	6,000	8,000	0.6	0.8
85	Middle Smithfield Twp. #1	2,000	4,000	6,000	0.4	0.6
Sub-Totals:		60,200	117,000	172,500		
Individual Plants						
86	Dingmans Twp. #1	1,000	2,000	4,000	0.2	0.4
87	Bossardville	1,000	1,200	1,500	0.2	0.2
88	Saylorsburg	2,500	5,000	7,000	0.5	0.7
89	Brodheadsville	3,000	4,000	5,000	0.3	0.3
90	Delaware Water Gap	1,500	2,000	2,500	0.3	0.3
91	Ross Corner	1,000	2,000	4,500	0.3	0.5
92	Sparta Twp. #1	500	1,000	1,500	0.1	0.2
93	Crandon Lakes	1,000	1,500	2,000	0.2	0.2
94	Hardwick Twp. #1	500	700	1,000	0.1	0.1
Sub-Totals:		12,000	19,400	27,000		
Existing Plants - Expansion or Reconstruction						
95	Stroudsburg	8,000	9,000	15,000	2.1	2.1
96	East Stroudsburg	10,500	12,000	20,000	3.1	3.1
97	Port Jervis	10,200	12,000	14,000	1.6	1.6
98	Newton	11,000	12,000	21,000	3.1	3.1
Sub-Totals:		39,700	45,000	70,000	95,100	

TABLE H-7
(continued)

WATER POLLUTION CONTROL PLANTS
DESIGN POPULATIONS AND PLANT CAPACITIES
ALTERNATIVE I

Construction Phase Three (2000-2020)			Design Capacity by Construction Period (MGD)	
Plant No.	Community or Area Served	Peak Summer Service Population	2000	2000-2020
"Zone" Plants				
99	Porter Twp.	3,000	5,000	0.5
100	Middle Smithfield Twp. #2	3,000	5,000	0.5
101	Analomink	5,000	7,000	0.7
102	McMichels Creek	2,000	3,000	0.3
Sub-Totals:			13,000	20,000
Individual Plants				
103	Town of Deerpark	1,500	2,000	0.2
104	West Fall Township	2,000	3,000	0.3
105	Dingman Twp. #2	2,500	3,500	0.4
106	Middle Smithfield Twp. #3	1,000	2,000	0.2
107	Price Twp.	500	700	0.1
108	Scots Run	500	1,000	0.1
109	Pocono Manor	2,000	3,000	0.3
110	Frankford Twp.	1,000	1,500	0.2
111	Sparta Twp. #2	1,000	1,500	0.2
112	Stillwater Twp. #2	1,500	2,000	0.2
113	Hardwick Twp. #2	2,000	2,500	0.3
114	Dingman Twp. #5	700	1,000	0.1
115	Delaware Twp.	1,500	2,000	0.2
116	Pocono Twp.	1,500	2,000	0.2
Sub-Totals:			19,200	27,700
Totals: ³			63,300	267,400
			487,800	673,600

1 Outside TIRES.

2 Including Suburban Areas.

3 Not including 141,500 from DWGNRA.

Alternative II - Limited Sub-Regional Systems

Description of Alternative II.--In Alternative I, 116 water pollution control plants would be built within the study area by the year 2020. Alternative III (to be discussed in the next section) is based on a sub-regional concept, and the number of major treatment plants in the study area would be reduced from 116 to 6. Alternative II is presented as an intermediate step between Alternatives I and III. It utilizes the sub-regional concept in part and provides for expansion of the sub-regional systems as the need occurs. In addition, those areas where the interconnection of collection systems is relatively costly will still be served by small, individual treatment facilities.

The most difficult question in the formulation of Alternative II was in deciding how far to extend the major trunk lines and interceptors for the limited sub-regional plants. The basic assumption was made to extend the lines only as far as the anticipated population densities would be continuous or relatively easy to interconnect. Those sub-drainage basins, or portions thereof, where interconnection of lines was not warranted would be served by the smaller systems. Within the National Recreation Area, clusters of recreational sites which are relatively isolated both from each other and development outside the DWGIRA, would also be treated by individual plants.

The major components of Alternative II are eight limited sub-regional systems as shown in Figure 2. The water pollution control plants at Matamoras, Milford, Barrett Township, and Paradise Township would be built initially in Phase 1 and expanded in Phase 2. Two of the plants (Lower Brodhead and Paulins Kill) would be built initially in Phase 1 and expanded in Phases 2 and 3. The final two sub-regional plants (located at Flatbrook and Snydersville) would be built initially during Phase 2 and expanded during Phase 3.

The eight limited sub-regional plants would have a total peak summer service population of approximately 721,000 by the year 2020. This represents about 81 percent of the total service population under Alternative II. The eight are relatively large systems, with two of the plants ultimately serving over 200,000 people each. A significant factor is that the limited sub-regional systems serve not only adjacent townships and counties but will extend their lines across state boundaries.

Several of the limited sub-regional plants also represent a cooperative effort by the National Recreation Area and the communities that border it; approximately 64,000 park occupants will utilize two of the eight plants. This represents over 45 percent of the total demand from the park area.

Matamoras Area System.--This system services the northern region of the study area, including Matamoras Borough, portions of Westfall Township in Pennsylvania, portions of Montague Township in

New Jersey, the city of Port Jervis, New York, and the adjacent suburban communities in the Towns of Deer Park, Mt. Hope, and Greenville. The initial stage of construction and development of the system excludes the demand of the Port Jervis area, since the existing public system should continue to function until sometime after 1985. During the second phase of construction, additional growth in the surrounding communities would be added to the plant. This would bring the total design capacity of the Matamoras plant to approximately 5.4 mgd by the year 2020.

The development of a wastewater treatment system for the Port Jervis-Town of Deer Park area in Orange County raises two major questions. First, how much will growth in this area be influenced by the development of the National Recreation Area and the construction of the reservoir? The population projections developed in this study give much weight to the relative influence of the DWGNRA. The projections indicate that the population for the year 2020 is expected to be greater than 22,000 people in Town of Deer Park. It is reasonable to assume that the bulk of this growth will occur in the valleys of the Delaware River, the Neversink River, and the Shingle Kill. Under Alternative II, it is assumed that the bulk of the future population growth would be distributed between these three sub-drainage basins, and the population density in the balance of the Town of Deer Park would still be so widely dispersed as to prohibit the collection and combined treatment of wastewaters. It is for this reason that two small plants, the Neversink Valley plant and the Shingle Kill plant are planned for development under construction Phase 2. The construction of these systems must be regarded as entirely dependent on the population growth within the Town of Deer Park, and their exact location and growth would be contingent on the population distribution within the two areas.

The second question raised in Orange County is the possible incorporation of the City of Port Jervis plant in a limited sub-regional system. The existing trickling filter plant at Port Jervis, while capable of serving the future demands of the city and some of its suburban communities, is not capable of serving as the nucleus for such a sub-regional system. Nor would it be practical to consider adding the loads from such potential growth communities as Matamoras and Montague Township to the existing plant's influent. This assumption is based on the high degree of treatment required and the inability of trickling filter plants to meet the requirements. It was for this reason that a new treatment plant across the Delaware River at Matamoras is planned under Alternative II.

The community of Matamoras should build a sewerage system and water pollution control plant now, and it should be designed to sustain the growth which this community and its surrounding area will undergo within the next 20 years. In addition to the initial demand of Matamoras Borough and the adjacent portions of Westfall Township, the first stage of this plant should also include capacity for the

early growth in the Millbrook sub-drainage basins of Montague Township and some of the suburban area surrounding Port Jervis. These component flows would be pumped across the new Interstate Highway 85 bridge and would discharge into the plant which would be situated at the south end of the Borough. Additional portions of Westfall Township in Pennsylvania, including the community of Millrift, and the upper Delaware Valley north of Port Jervis will eventually be served by the Matamoras Plant, but not until development warrants construction of those increments of interceptor.

A final consideration under this system is whether construction of a separate treatment plant at Matamoras is justified in lieu of pumping the collected raw sewage south to the proposed treatment plant at Milford. It would be possible to construct a large force main along the right-of-way of Interstate Highway 84 and continue down the route of existing Highway U.S. 209 to the Milford plant site, a distance of almost 7 miles. For the range of expected flows at the proposed Matamoras plant, the pumping operation would prove slightly less expensive both in terms of first cost and operation, than the separate treatment facility. However, since the Milford plant would be situated within the National Recreation Area and will be adjacent to several large recreational areas within the DWGNRA, it was felt that placing this additional burden of over 5 mgd on the plant was not warranted.

Milford-Montague area.--The construction of a water pollution control plant south of the borough of Milford, and the development of a sub-regional system to serve both the Pennsylvania and the New Jersey environs, including DWGNRA areas, has sound economic and technical bases. Within a radius of six and one half miles of the proposed plant site there will be 6 major recreation areas with a total peak summer population of over 60,000 occupants served by the year 1985.

Development in the region outside of the DWGNRA limits will also be extensive, with the adjacent community of Milford expected to grow from its present population of 1,700 people to over 5,000 people in the peak summer period of 2020. The smaller communities across the river in New Jersey, such as Millville and Montague, will also undergo rapid growth as the park develops. This portion of Montague Township will be choice real estate, and is expected to have a summer peak population of over 15,000 people by the year 2020. The large majority of these people will be within the service area of this sub-regional system. Their wastewaters will be collected at the eastern end of the Delaware River bridge, and there combined with the flow pumped north along the New Jersey edge of the reservoir from the park areas of Sandyston, Namanock and Minisink. The combined flow will then cross the Delaware River bridge in a gravity line to the plant site. This total cumulative flow from the New Jersey area during maximum occupancy of the Recreation Area in the summer months will reach an average daily rate of some 2.3 million gallons. The major portion of this

flow, some 1.7 million gallons per day, will be generated by the DWGNRA facilities which, of course, will be in use only during the summer. This is an indication of how great a demand fluctuation must be considered in the detailed engineering design of this particular treatment plant.

The variation in wastewater flow rate becomes an even greater problem when the Pennsylvania service areas are added. The total flow in this sub-regional system and plant by the year 2020 would reach a peak of over 5.5 mgd. Of this total demand, some 2.4 mgd would be produced by the 60,000 park occupants in the nearby sites. The remaining 3.1 mgd would be generated by the permanent and summer residents in the adjacent portions of Dingman, Milford and West Fall Townships in Pennsylvania, as well as the Borough of Milford, and the portion of Montague Township previously mentioned.

With essentially no flows from the DWGNRA facilities during the winter months, the flow of the plant would decrease to probably less than 2 mgd. Therefore, the plant must, in effect, be a plant within a plant. That is, it must be designed in parallel units which can provide the same treatment process for greatly reduced flows, without sacrificing degree of treatment efficiency.

The major trunk lines and interceptors within the DWGNRA would probably shut-down during the 7 or 8 winter months. Since the flow of wastewaters from the New Jersey area across the bridge would be by gravity, a fluctuating pumping rate can be avoided. With intelligent planning and design, the plant and its collection system could grow as the area grew and meet the demand as it occurred rather than anticipating it too far in advance. The construction of trunk sewers back into the inland plateau regions of Milford Township would be feasible within 10 to 15 years, during construction Phase 2, but would not be a part of the initial construction and systems developments.

Pocono Plateau area.--The development which will occur on the Pocono Plateau in Pennsylvania in the Townships of Lehman, Delaware, and Dingman, will not be serviced by any of the eight sub-regional plants. The interconnection of service areas along the face of the Plateau, whether the wastewaters flow north to the Milford Plant, or south to a similar plant in the Bushkill inlet area, is not felt to be justifiable under Alternative II.

The National Recreation Area facilities from Lehman (National Park Site No. 4) north to Indian Point (N.P.S. No. 12), will have a total peak capacity of over 26,000 people. However, these park areas are spread along 15 miles of rugged mountain terrain. The park occupants will be distributed between 9 waterside sites, situated at elevation 410, and 21 upland camping and picnic sites, at elevations 400 feet higher. Most of these areas will represent small concentrations of people, with the exception of the Dingman's Creek area. Almost all of these facilities are grouped in clusters around the inlets of 7

small creeks which drain from the Plateau down the face of the escarpment. The interconnection of the wastewater collection systems for these isolated clusters, even utilizing the right-of-way of the proposed realigned highway U.S. 209, would involve a great deal of pumping and major trunk line construction to justify the advantage of more centralized treatment.

Present development patterns indicate that the anticipated future land use of the inland Pocono Plateau for summer homes will be quite extensive. In many of the small drainage basins such as Little Bushkill Creek, Toms Creek, Hornbeck Creek, Dingmans Creek, Raymondskill, and Sawkill, the summer populations will grow from little or nothing at the present time to several thousand people by the year 1985. As this growth occurs, it is advisable to combine the wastewaters collected from these homes with the park facilities confined within each respective sub-drainage basin. Projected population figures for the year 1985 estimate a peak load of 8,000 people within service area limits in seven sub-basin areas, increasing to over 53,000 people by 2020, with the extension of collection lines up the stream valleys. Combined with the park population of over 26,000, this represents a total peak summer population of almost 80,000 people in the Pocono Plateau area by 2020.

This is a significant number of people within the study area, and poses a very real pollution hazard to these small streams. Since each stream is the nucleus of recreational clusters within the DWGNRA, it is essential that the inland basin be protected from pollution.

Under this Alternative, five joint facilities are proposed to combine treatment for Recreation Area occupants with residents outside the DWGNRA: small plants would serve isolated recreation sites. Since upland development is virtually non-existent at the present time, (and probably will lag behind DWGNRA development) the initial plant capacities for the joint facilities will be designed primarily for DWGNRA demand. The future extension of trunk sewers up the drainage basin of each small creek must be correlated with the growth of each area and will vary with each line.

Where major DWGNRA facilities are located adjacent to the reservoir, the treatment facilities necessary for the immediate cluster of recreation areas will be built at or about elevation 440, the anticipated high water elevation of the reservoir. Where the recreation facilities to be served are primarily upland development and lie along the upper plateau, the treatment facilities will lie further inland on the creek, and their effluent will discharge to the creek rather than to the reservoir.

The proposed joint treatment facilities required for this plateau area are shown as plants 9 through 13 on Figure 2. Tables H-8 and H-9 also provide a listing of facilities, including demand, capacity, and population served, both initial and ultimate, for each small plant site.

Barrett Township - Paradise Township area.--Separate collection and treatment systems were considered for the areas of Barrett Township, Paradise Township, and the Borough of Mt. Pocono under Alternative I. In Alternative II, the systems serving several small communities in Barrett Township and the future growth area in the upper Brodhead drainage basin remain the same as in Alternative I.

This cluster of small communities, including Buck Hill Falls, Mountain Home, Cresco, and Canadensis should be a priority area for liquid waste disposal within the study area. These communities, and their related recreational development facilities, had a permanent population of some 2,400 people in 1960. Estimated peak summer populations for 1966 is over 6,000 people within the Township. By the year 2020, this number will climb to over 33,000 summer residents.

A system to serve this priority area is shown on Figure 2 with a proposed combined treatment facility located south of the community of Canadensis on the Brodhead Creek. This plant would have an initial design capacity of 1.2 mgd and would be expanded under construction Phase 2 to a capacity of 3 mgd.

The community of Mt. Pocono Borough has a present population slightly over 1,000 and an estimated peak summer population of over 2,600 by 1985; the community is experiencing extensive problems with its present on-site disposal systems. A feasibility study completed late in 1965 recommended that a system be designed to serve the central region of the Borough initially, with ultimate plans to serve the entire borough and surrounding developments.

A question raised in the feasibility report was whether or not the wastewaters from this community should be combined with the flows from present and future growth areas in adjacent Paradise Township. The combination of treatment facilities from Mt. Pocono Borough with any of the adjacent communities (particularly those surrounding Swiftwater in Pocono Township or the community of Paradise Valley in Paradise Township) will involve 2 to 3 miles of trunk sewer which will travel through what are now undeveloped areas. However, based on long range population projections, Paradise Township is expected to grow to a peak summer population of over 43,000 people by the year 2020. Recognizing this growth factor, it is felt that a combined treatment facility could be developed in this Alternative with a plant located northwest of Henryville, adjacent to the Paradise Creek.

This facility would treat the wastewaters from Mt. Pocono Borough, the development areas along U.S. Highway 611, the community of Swiftwater, existing pockets of small developments surrounding that area, the communities along State Highway 940 to the west of Swiftwater, and virtually all the future development in Paradise Township. Development in this general area is spotty at present; however, building a wastewater system along the main access routes and within the main drainage basins will adequately serve this prime recreational area.

A single, sub-regional plant system to serve the communities of Barrett, Paradise and Price Townships, as well as the community of Mt. Pocono Borough does not appear to be practical under this Alternative. Although an immediate need exists, the combination of the wastewaters by interceptors paralleling the two major streams in the area, Paradise Creek and the Brodhead Creek, and combined treatment at a plant site at the southern end of Price Township does not appear desirable under this Alternative.

Lower Brodhead area.--The Stroudsburg-East Stroudsburg area lends itself readily to the development of a single sub-regional system. Under Alternative II, such a system is proposed, but the network of trunk and sub-trunk sewers is not as extensive as will be discussed under Alternative III. Several possible plant sites are available. It would appear that the most desirable site is in the region of the confluence of the Brodhead Creek and the Delaware River. The plant could be located to the south and east of the community of Minisink Hills, and would occupy a presently vacant tract of land.

One of the initial components to be built would be an interceptor running down the valley from the Bushkill inlet area to Marshall's Creek. This line would serve the DWGNRA developments around the inlet and the extensive commercial and residential development taking place in this valley. The fact that this service region is a prime recreational and commercial area is demonstrated by the present construction of new motels and hotels along U.S. 209. This interceptor, after running 5-1/2 miles from the inlet to the community of Marshall's Creek, would then turn south down the valley of Marshall's Creek for another 3-1/2 miles to the plant site. At the junction point of Marshall's Creek, the wastewater flow would be augmented by smaller lines running down Pennsylvania Highway 402 and from the west along U.S. 209. Development in the upper drainage basin of Marshall's Creek could be discouraged by limiting construction of sewer lines to 1-1/2 or 2 miles above the community. This stream valley is one of the areas recommended for reservation as "open space," and would be an excellent site for a reservoir, necessary to augment future water demands.

The community of Stroudsburg is presently served by a 1 mgd trickling filter plant, located at the eastern edge of the Borough adjacent to Brodhead Creek. This plant, initially constructed in 1937, was severely damaged by floods in 1955, and has undergone extensive modernization. While the treatment capacity of the plant has not been increased, the maintenance and operation afforded this facility indicates that it can continue to carry the burden of the municipal wastewaters from the borough for some time.

South of the Stroudsburg plant and across the Brodhead Creek on the south side of Interstate Highway 80, is the treatment facility which serves the Borough of East Stroudsburg. This plant was put into operation in 1961 and is already near its design capacity. The original design capacity of 1 mgd was felt to be capable of handling the demands of the Borough from some time. However, enlargement of the

Borough by the addition of several areas in Smithfield Township has increased the average daily flow to this plant to over 1 mgd. Good operation and maintenance have minimized the problems resulting from this plant, but it is recognized that it must be supplemented by additional treatment capacity in the near future.

Because of their limited land areas, neither plant lends itself readily to significant expansion in the future. Since the Boroughs of Stroudsburg and East Stroudsburg anticipate a total future population of some 38,000 by 2020, it is obvious that the existing facilities cannot meet the future demands. With the development of a sub-regional system, both of the existing systems would be integrated into the larger system as the present plant capacities are reached.

As shown on Figure 2, an interceptor would run down the Brodhead Creek passing both plant sites. In this way, both plants would continue to operate at their maximum loading during Phase 1 while the overflow was diverted and carried on to the larger treatment plant further downstream. As the areas around the Boroughs developed, the lines serving them would discharge directly into the new interceptor. In this way, key areas such as the Industrial Park to the north of East Stroudsburg and portions of Stroud Township could be served immediately. The two existing plants would be abandoned during Phase 2 and the flows to the plants diverted into the interceptor.

The community of Delaware Water Gap would also be included in the initial service area. However, further extension of lines up the valley of Cherry Creek is not planned under this Alternative. The lower or eastern region of the valley would remain undeveloped, and only rural residential development should be encouraged.

The trunk line running parallel to U.S. Highway 611 down the valley of the Pocono Creek, serving Pocono, Jackson, and the upper reaches of Stroud Township, would not be part of the first construction phase, but would be developed during the second and third stages. Some reaches of the upper Pocono basin will eventually be served by small systems as isolated development occurs.

The treatment capacity required at the various stages of growth for the lower Brodhead Plant and the development of system components is shown in Tables H-8 and H-9.

The population projections discussed earlier indicate that the boroughs of Stroudsburg, East Stroudsburg and Delaware Water Gap and the related suburban communities of Stroud and Smithfield Townships will grow from their 1960 resident population of less than 22,000 to well over 57,000 by the summer of 1985. With adjacent Middle Smithfield increasing to over 28,000 within the same period, the potential wastewater loading would be almost 8.6 mgd within a 6 mile radius of the plant. The bulk of this flow would be served by the proposed system, with the two existing plants continuing to handle a portion of the load until Phase 2.

The flow from portions of Smithfield, Middle Smithfield, and Stroud Townships as well as Delaware Water Gap Borough and some DWGNRA sites is estimated at 4.5 mgd by 1985. Thus, the capacity of the proposed Lower Brodhead sub-regional plant must be capable of increasing from less than 1 mgd (1975) to over 4 mgd within 10 years (1985), increasing again to almost 7 mgd as the two existing plants are phased out, and ultimately handling 22 mgd by the year 2020.

Paulins Kill area.--The gently rolling hills and pleasant valleys that form the drainage basin of the Paulins Kill make this area unique in many respects. Covering over 112,000 acres, most of which would be ideal for residential and recreational development, it is the largest single sub-drainage basin within the study area. It also possesses the greatest potential for development, particularly of a permanent nature. The terrain is different in character from the plateaus and steep valleys of Pennsylvania to the west, and also from those portions of New Jersey which lie beyond the Appalachian ridge. The 16 lakes which line the valley provide an ideal nucleus for recreational development. With its many natural assets, plus a good road system, the area possesses a large potential for future population growth. The present summer population is less than 40,000 people; by the year 1985 the peak summer population is expected to increase to over 122,000 people. This will not represent the maximum holding capacity of the basin, and its future growth should continue at a rate higher than the balance of the study area.

Future anticipated growth warrants a single, sub-regional system. However, extensive development is not present now. Isolated areas of development do exist and have immediate but minor needs for liquid waste disposal. The Borough of Newton is the major community within the drainage area and is presently served by a 1 mgd plant. As recently as 1966 this plant underwent extensive revision and modernization. Although its total capacity has not been increased, it is expected that it will be able to meet the limited growth within the Borough for the next 20 years. It cannot, however, carry the burden of the extensive growth anticipated in the immediate area surrounding the Borough. Again, it is necessary to complement, and eventually integrate, the existing system components.

Under Alternative II, an extensive sub-regional system is proposed to serve the entire Paulins Kill drainage basin. Obviously, there will be some components of the system that will be inefficient initially and there will be large trunk lines and interceptors which will carry the collected wastewaters through areas which are not yet developed.

If the concept of sub-regional system is discarded, and individual systems are provided for such communities as Branchville, Swartswood, Blairstown and Columbia, it is felt that an optimum solution will not be effected. From the most recent data on permanent and summer home building, it appears that the entire valley will develop. Therefore,

development of a sub-regional system for the Paulins Kill would represent intelligent planning for an anticipated future need, and eventually would serve nearly everyone who will live within the valley.

The components of the system would be developed in stages; the first main interceptor, paralleling the Paulins Kill and running from the upper sub-basin some 23 miles south to the area of Columbia, would be one of the first required steps. Actually, a wastewater collection system to serve the Paulins Kill area should begin at the northeast corner of the drainage basin in the area of Culvers Lake. This prime growth area, already experiencing extensive recreational development, will undergo even greater growth in the future. The nearby community of Branchville, lying to the south and east on Route 206, is expected to grow from a present day permanent population of less than 1,000 to a recreational and residential center of almost 5,000 by 2020. The township of Frankford, in which Culvers Lake, Lake Owassa, and Branchville are located, will reach a total peak summer population of some 41,000 by the year 1985. The entire upper valley paralleling U.S. 206 will experience growth in the very near future. This then should be one of the first major service areas of the collection system and should be served in the initial stage of construction.

Approximately 10 miles south of Branchville lies the borough of Newton with a 1960 resident population of 6,563 and a 1966 peak summer population of over 8,300. Considering this seasonal growth, the existing Borough facilities are adequate. Population projections for the Borough indicate large gains within the next 20 years with increases of peak summer population to 14,000 by 1985. By 2020, the population in the Borough will be over 22,000. If this growth occurs as expected it will surpass the capacity of the existing Borough treatment facilities.

Certain of the new lines constructed under Alternative II would be integrated with the existing collection system, but most of them would by-pass the existing lines and drain to a low point at the north end of the borough. At this point, a force main would pump the collected wastewaters north, paralleling U.S. 206, over the ridge line. The line would then flow by gravity into the valley of the Paulins Kill, joining with the large trunk sewer from the Culvers Lake - Branchville area. A third line, running from the Lake Mohawk area to the southeast, and through the communities of Lafayette and Ross Corner would be added at the same point. The development of this third component paralleling State Highway 15 should occur during the second construction Phase.

From the junction point of these three lines, the main interceptor would run to the southwest down the valley, paralleling the Paulins Kill.

Most of the present growth and much of the anticipated future growth lies close to the center of the valley, and so the components of the system draining the facilities around Swartswood Lake, Paulins

Kill Lake and the communities of Stillwater, Middleville, Blairstown, Hainesburg, and Columbia would all be built as part of the first stage of construction. The several components of lines running back into the hills to serve the lakes, camp areas, and summer homes, should not be built until the demand for each line was sufficient to warrant it.

The sub-regional water pollution control plant would be located to the northeast of Columbia, near an existing, small reservoir. The design of the plant should include an effluent discharge line running below the existing reservoir into the Paulins Kill.

This sub-system, and its various stages of growth, are shown on Figure 2.

Flat Brook area.--The construction of a single sub-regional water pollution control collection system to serve the DWGNRA facilities on the Flat Brook Peninsula and those which line the Flat Brook inlet, as well as the residential development within the drainage basin of the Little Flat Brook to the north, does not appear desirable in this Alternative II. The interconnection of lines between the widely dispersed facilities which will lie along the edge of the Peninsula and the face of the Kittatinny Ridge would have a high initial construction cost, and would present operating and maintenance problems. While no high-lift pumping would be necessary to service any of the individual areas, extensive low-lift pumping facilities would still be required.

The advantage gained in the combined treatment of the wastewaters would be lost by the detrimental effect of a large plant located near Peters Valley, at the Upper end of the Flat Brook inlet. A plant with the required peak capacity of over 3.6 mgd would discharge this effluent to the inlet. Since this Flat Brook inlet is shallow at its upper end, and the flow of the two streams running into it is relatively low during the summer periods, effective effluent dispersal would be difficult. A smaller treatment plant, to handle only the wastewaters from the Little Flat Brook basin, could be constructed further up this Little Flat Brook Creek; the effects of this plant would be only 60 percent of the BOD loading to the stream from a combined facility.

Thus, under Alternative II, a sub-regional plant is proposed to serve the heart of Sandyston Township, with a trunk interceptor roughly paralleling the Little Flat Brook Creek, running south through the communities of Hainesville and Layton, to the Peters Valley area. By 1985, the peak population to be served by this and several other small sub-trunk sewers would be approximately 8,000 people, increasing to 22,000 by 2020. The plant would be constructed in the area of Peters Valley outside the limits of the DWGNRA and far enough upstream in the Little Flat Brook to provide adequate aeration and effluent dispersion. The development of these facilities would be independent of the Recreation Area demands.

Those recreation areas along the Flat Brook Peninsula which can be combined and treated as a group are also shown on Figure 2. Across the inlet on the face of the Kittatinny Ridge, a number of facilities at the waters edge will be combined and will include upland developments and camp sites.

A further consideration for those facilities which line the inlet is the dilutional capacity of the wide shallow inlet and the effect of multiple small effluent discharges. As long as the degree of treatment can be kept high and the facilities carefully operated, water quality can be protected. These plants are also shown on Figure 2.

For those isolated upland developments located along the south end of the Kittatinny Mountain, in what was formerly Pahaquarry Township, individual treatment facilities appear to be the most desirable solution under this Alternative II, as well as all other alternatives.

Snydersville area.--Along the sub-drainage basin of the McMichael's Creek, running from eastern Chestnut Hill Township through Hamilton Township, there are several small communities which could be served by small systems such as those proposed under Alternative I, or might combine their systems, as shown under this Alternative. It is unlikely that development within this sub-basin would be sufficiently intense to warrant inclusion in the Lower Brodhead Plant under this Alternative.

In order to protect the lower reaches of the stream, which runs through Stroud Township, systems should be developed to serve these communities by the second construction phase with a planned service population of 30,000 people by the year 2020. A plant would be located in the vicinity of Snydersville, adjacent to the McMichael's Creek. The extent of the system and development staging is shown on Figure 2 and pertinent data presented in Tables H-8 and H-9.

TABLE H-8
WATER POLLUTION CONTROL PLANTS
DESIGN POPULATIONS AND PLANT CAPACITIES
ALTERNATIVE II

Plant No.	Community or Area Served	Peak Summer Service Population			Design Capacity By Construction Period (MGD)		
		Population			Phase 1	Phase 2	Phase 3
		1985	2000	2020	1970-1980	1980-2000	2000-2020
<u>Limited Sub-Regional Plants</u>							
1	Matamoras	18,000	42,000	54,000	2.0	5.4	5.4
2	Milford	70,000	82,000	91,000	3.4	5.5	5.5
3	Barrett Township	12,000	18,000	30,000	1.2	3.0	3.0
4	Paradise Township	15,000	30,000	45,000	1.5	4.5	4.5
5	"Lower Brodhead"	43,000	134,000	214,000	4.2	14.0	22.0
6	"Paulins Kill"	85,000	157,000	230,000	9.0	16.0	24.0
7	"Flatbrook"	8,000	17,000	22,000		1.7	2.2
8	Snydersville		15,000	30,000		1.5	3.0
	Sub-Totals:	251,000	495,000	716,000	21.3	51.6	69.6
<u>DWGNRA - Joint Facilities</u>							
9	"Raymonds Kill"	4,900	12,000	18,400	0.3	2.0	2.0
10	"Dingmans Creek"	14,800	18,800	22,800	0.7	1.5	1.5
11	"Hornbecks Creek"	6,800	9,300	12,300	0.4	1.0	1.0
12	"Toms Creek"	3,400	8,400	11,400	0.2	1.0	1.0
13	"Little Bushkill"	4,400	10,400	14,400	0.3	1.3	1.3
<u>DWGNRA Only</u>							
14-42	(24) Individual or Combined Small Plants	51,200	51,200	51,200	2.2	2.2	2.2
	Sub-Totals:	85,500	110,100	130,500	4.1	9.0	9.0

TABLE H-8
(continued)
WATER POLLUTION CONTROL PLANTS
DESIGN POPULATIONS AND PLANT CAPACITIES
ALTERNATIVE II

	Additional Small Plants								
43	"Neversink Valley"	8,500	9,000	0.8	0.9				
44	"Shingle Kill"	2,000	3,000	0.3	0.3				
45	"Porters Lake"	3,000	5,000	0.3	0.5				
46	Bossardville	1,500	2,000	0.2	0.2				
47	Price Township	3,000	5,000	0.5	0.5				
48	"Pocono"	2,500	4,000	0.4	0.4				
49	Hampton Township	5,000	7,000	0.5	0.7				
50	Dingman Township		5,000	0.5	0.5				
51	Town of Deer Park		2,000		0.2				
52	Middle Smithfield		5,000		0.5				
	Sub-Totals:	25,500	47,000	3.5	4.7				
	TOTALS:	336,500	630,600	25.4	64.1	83.5			

TABLE K-9
WATER POLLUTION CONTROL PLANTS
SYSTEMS DEVELOPMENT SUMMARY
ALTERNATIVE II

Plant No.	Community or Area Served	Population Distribution	Peak Summer Service Population		
			1985	2000	2020
1	Matamoras		18,000	42,000	54,000
2	Milford	DWGNRA Outside	60,000 10,000	60,000 22,000	60,000 31,000
3	Barrett Township		12,000	18,000	30,000
4	Paradise Township		15,000	30,000	45,000
5	"Lower Brodhead"	DWGNRA Outside	4,000 39,000	4,000 130,000	4,000 210,000
6	"Paulins Kill"		85,000	157,000	230,000
7	"Flatbrook"		8,000	17,000	22,000
8	Snydersville			15,000	30,000
9	"Raymonds Kill"	DWGNRA Outside	3,400 1,500	3,400 8,600	3,400 15,000
10	"Dingmans Creek"	DWGNRA Outside	12,800 2,000	12,800 6,000	12,800 10,000
11	"Hornbecks Creek"	DWGNRA Outside	5,300 1,500	5,300 4,000	5,300 7,000
12	"Toms Creek"	DWGNRA Outside	2,400 1,000	2,400 6,000	2,400 9,000
13	"Little Bushkill"	DWGNRA Outside	2,400 2,000	2,400 8,000	2,400 12,000
14-42	DWGNRA (Small Plants)		51,200	51,200	51,200
43	"Neversink Valley"			8,500	9,000
44	"Shingle Kill"			2,000	3,000
45	Porter Township			3,000	5,000
46	Bossardville			1,500	2,000
47	Price Township			3,000	5,000
48	"Pocono"			2,500	4,000
49	Hampton Township			5,000	7,000
50	Dingman Township				5,000
51	Town of Deer Park				2,000
52	Middle Smithfield				5,000
TOTALS: (1)			336,500	630,600	893,500
TOTALS: (2)			195,000	489,100	752,000

(1) Including 141,500 from DWGNRA
(2) Not including 141,500 from DWGNRA

Collection System					
Major Sewer Lines (Miles)			Pump Stations		
Phase One	Phase Two	Phase Three	Phase One	Phase Two	Phase Three
27	8	1	11	2	
22	13		25	5	
7	3		2	0	
9	6		3	2	
30	30	20	15	6	4
40	80	20	40	9	1
	7	2		2	0
	15	9		4	1
6			5		
5	6	2	1	2	0
5					
5	4	2	2	2	1
6					
1	4	0	2	1	1
3			4		
1	5	1	3	0	0
4			3		
4	3	1	3	2	0
20	0	0	10	0	0
	8	4		6	
	4			3	
	3			1	
	2			2	
	4			3	
	5			4	
	2	1		2	0
		1			1
		1			
		<u>1</u>			
195	212	66	129	58	9

Alternative III - Sub-Regional Systems

Description of Alternative III.--Under Alternative III, the number of treatment facilities is reduced to six in order to reduce the construction, operation, and maintenance costs of treatment and to exercise a greater degree of control over effluent quality and protection of the environment.⁽¹⁾ Four of the sub-regional plants in Alternative III are expanded versions of the limited sub-regional plants discussed under Alternative II, and the other two sub-regional plants are combinations of the limited facilities in Alternative II. Each collection system still attempts to follow the natural drainage patterns wherever possible.

As under Alternative II, the six plants in Alternative III have been located as closely as possible to the regions which they will serve. Each sub-regional treatment plant will eventually be served by an extensive collection system, portions of which can be developed in stages. However, because of the widely diversified demand in some areas, the staging of collection system construction will be much more difficult under this Alternative.

Three of the six plants will discharge their effluent directly to the reservoir, and one will discharge into the head waters of the Upper Brodhead Creek.

Sub-regional wastewater treatment system No. 1 - Matamoras - Orange County area.--This sub-regional treatment facility would be located southeast of Matamoras Borough, on what was formerly the airport runway and adjacent to Interstate Highway 84. The system would serve that portion of Orange County, New York in the study area, the drainage basin of Mill Brook in Montague Township, New Jersey, and that portion of West Fall Township in Pennsylvania which drains into the Delaware River from Matamoras Borough north to Millrift.

Under Alternative III, this sub-regional system extends its service area into the upper reaches of the Town of Deer Park in Orange County and collects from those areas which were served under Alternative II by the two small plants identified as the Neversink Valley and Shingle Kill plants. In order to accomplish this, an interceptor would run from the upper reaches of the Neversink Valley near the Orange County line, south to the junction of the Basher Kill and then continue down the valley to Port Jervis. This would serve all of the eastern section of the Town of Deer Park.

In the western portion of the Township, another interceptor would run from the small community of Rio down the drainage basin of the Shingle Kill to the Delaware River Valley. There it would be joined

(1) In addition to the six sub-regional plants, there are 15 very minor facilities serving isolated areas. These 15 facilities only serve about one percent of the service population and so are not elaborated upon herein.

by a smaller line running from the Mongaup Valley down the Delaware and another crossing the Delaware from several small drainage basins in West Fall Township of Pennsylvania. The combined flows would run south paralleling New York State Highway 97, through the City of Port Jervis and across the bridge to Matamoras.

As mentioned previously, Port Jervis is presently served by its own collection system and treatment plant. Under this Alternative, consideration was given to utilizing this plant as the nucleus for the sub-regional system. However, preliminary investigation indicated that this plant was not capable of providing the desired capacity of the future regional system and indicated that a new plant must be constructed. Therefore, it is again assumed that the existing plant will eventually be phased out and integrated into the Matamoras sub-regional system.

The system is shown graphically in Figure 3. As shown in Tables H-10 and H-11, the system will represent an aggregate of 24 miles of major trunk and interceptor lines and 68 miles of smaller sewer construction. The system will also involve a number of lift stations, ten of which will be located along the main interceptor and twelve smaller lift stations on the smaller lines.

The water pollution control plant capacity necessary to ultimately serve this entire area, including the demands of Port Jervis City, will be approximately 7 mgd by the year 2020. Like other plant operations, the demand on the plant will be constantly increasing during the design life, but the relative increases will be much less than for many of the other sub-regional plants. The fluctuation between winter and summer demands will also be less because population growth influx in the area is expected to be of a more permanent nature. For this reason, the major construction effort for both the collection system and the treatment plant would be necessary under the first two construction phases.

Sub-regional wastewater treatment system No. 2 - Milford area.--The sub-regional water pollution control plant would be located south of the Borough of Milford, Pennsylvania, east of the junction of U.S. Highways 6 and 206, and north of the Delaware River bridge crossing. The system would serve the Delaware Water Gap National Recreation Area facilities on the Pennsylvania side of the reservoir from Lehman (N.P.S.NO.4, Hill Farm Section) north to Milford and in New Jersey from Sandyston (N.P.S.NO.18, Minisink Section) north to Millville. Included also in the service area are the sub-drainage basins of the 7 small streams which drain the Pocono Plateau in Pennsylvania in the Townships of Lehman, Delaware, Dingman, and Milford. In addition, the Borough of Milford in Pennsylvania and the western portion of Montague Township in New Jersey are included.

Under Alternative II, a plant at Milford was proposed to serve National Recreation Area sites and the Pennsylvania and New Jersey

TABLE H-10
WATER POLLUTION CONTROL PLANTS
DESIGN POPULATIONS AND PLANT CAPACITIES
ALTERNATIVE III

Sub-Regional Plant No.	Name	Service Area	Peak Summer Service Population		Design Capacity by Construction Period (MGD)			
			1985	2000	2020	Phase 1 1970-1980	Phase 2 1980-2000	Phase 3 2000-2020
1	Matamoras - Orange County	Port Jervis City and Town of Deerpark, N.Y.; Mill Brook Basin, N.J.; West Fall Twp., Penna.	35,000	55,000	70,000	3.5	5.5	7.0
2	Milford	DWGNRA Facilities in Penna. and N.J.; Lehman, Delaware, Dingman and Milford Twps., Penna; Mon- tague Twp., N.J.	118,000	170,000	190,000	8.6	11.6	13.6
3	Flatbrook	DWGNRA Facilities in N.J.; Little Flat Brook and Flat Brook Basins, N.J.	43,000	50,000	55,000	2.4	3.1	3.6
4	Upper Brodhead	Barrett, Price, Paradise Twps. and Mt. Pocono Boro in Penna.	30,000	75,000	110,000	3.0	7.5	11.0
5	Lower Brodhead	Lower Brodhead Creek, Pocono Creek and McMichel Creek Basins in Monroe Co., Penna.	60,000	170,000	280,000	6.0	17.0	28.0

TABLE H-10
(continued)

WATER POLLUTION CONTROL PLANTS
DESIGN POPULATIONS AND PLANT CAPACITIES
ALTERNATIVE III

Sub-Regional Plant No.	Name	Service Area	Peak Summer Service Population		Design Capacity by Construction Period (MGD)			
			1985	2000	2020	Phase 1 1970-1980	Phase 2 1980-2000	Phase 3 2000-2020
6	Paulins Kill	Paulins Kill Basin in Warren and Sussex County, N.J.	95,000	160,000	220,000	9.5	16.0	24.0
		Sub-Totals:	381,000	680,000	925,000	33.0	60.7	87.2
	Individual Facilities (4) plus		4,800	7,800	12,000	0.2	0.5	0.9
	Isolated DWGNRA Sites (11)							
	TOTALS: ¹		385,800	687,800	937,000	33.2	61.2	88.1
	TOTALS: ²		244,300	546,300	795,500			

¹Including 141,500 from DWGNRA

²Not including 141,500 from DWGNRA

TABLE H-11
SUMMARY OF SYSTEM COMPONENTS
ALTERNATIVE III
SUB-REGIONAL SYSTEM NO. 1

Construction Stage	Service Population	Major Sewer Lines (Miles)		Pump Stations		Treatment Plant Average Daily Flow (MGD)	
		Trunk	Sub-Trunk	Major	Minor	Winter	Summer
Phase One (1970-1980)	35,000 (1985)	10	20	5	4	2.2 (1985)	3.5 (1985)
Phase Two (1980-2000)	55,000 (2000)	10	35	4	6	3.0 (2000)	5.5 (2000)
Phase Three (2000-2020)	70,000 (2020)	4	13	1	2	5.0 (2020)	7.0 (2020)
TOTAL		24	68	10	12		

communities within a 6 mile radius of the Borough of Milford. The extension of lines was limited to drainage basins that could be served primarily by gravity lines with relatively little pumping effort. Under Alternative III, the same service areas are included; however, a large trunk line running from the south along the face of the Pocono Plateau is added. This line would be comprised of a series of force mains and gravity lines. Several alternative routes for such a trunk line have been evaluated, but it was determined that, with the relocation of U.S. Highway 209 onto the Plateau, the most economical solution would be to build the trunk line and the pumping stations within the right of way of the relocated highway. This would necessitate close planning and coordination with the construction of the road.

This main trunk line would be over 17 miles long and would collect the wastewaters from most of Lehman Township, Delaware Township, and Dingman Township. The steeply eroded terrain which typifies the edge of the escarpment dictates alternating gravity lines and force mains. If the line were placed in the excavated right of way of the relocated U.S. 209, the cost of excavation and placement would be minimized. Some of the most difficult connections would be the lines which run to the National Recreation Area sites situated at the water edge, several hundred feet below the elevation of the proposed trunk line. The wastewaters from these sites must be pumped back up the steep drainage courses of the small streams on which they are situated; wherever possible, this should be done by utilizing the shoulders of proposed access roads.

Along the 17 mile length of this main trunk line, 27 DWGNRA centers would be served, representing a total peak population of over 26,000 people. Although this represents a significant portion of the demand flow initially, the use of this line by people outside the DWGNRA would eventually exceed the Recreation Area demands. It is estimated that in 1985 some 25,000 people will occupy the inland drainage basins which will connect to this trunk line. By the year 2020, the development of summer homes and recreational facilities on the inland Pocono Plateau will increase this number to over 61,000 people during the summer period. Thus the maximum, average daily flow which this component of the system must ultimately carry is over 7 mgd, with over 6 mgd generated by residents outside the DWGNRA.

The capacity of the plant at Milford would be 14 mgd by the year 2020. This will serve a population of over 190,000 people, some 84,000 of which will be within the National Recreation Area.

Sub-regional wastewater system No. 3 - Flat Brook area.--
The sub-regional treatment facility for this system would be located at the confluence of Flat Brook and Little Flat Brook Creeks, near the community of Peters Valley in Sandyston Township, New Jersey. The system would serve the southern section of the DWGNRA on the New Jersey side of the reservoir along the Kittatinny Mountain ridge and the Flat Brook Peninsula (National Recreation Area sites N.P.S. Nos.

TABLE H-12
SUMMARY OF SYSTEM COMPONENTS
ALTERNATIVE III
SUB-REGIONAL SYSTEM NO. 2

Construction Stage	Service Population	Major Sewer Lines (Miles)		Pump Stations		Treatment Plant Average Daily Flow (MGD)	
		Trunk	Sub-Trunk	Major	Minor	Winter	Summer
Phase One (1970-1980)	118,000 (1985)	30	15	25	41	2.5 (1985)	8.6 (1985)
Phase Two (1980-2000)	170,000 (2000)	25	10	5	4	4.8 (2000)	11.6 (2000)
Phase Three (2000-2020)	190,000 (2020)	5	3	3	3	7.0 (2020)	13.6 (2020)
TOTAL		60	28	33	48		

19 through 30). Outside DWGNRA, the Little Flat Brook and Flat Brook drainage basins would be served.

The development of a sub-regional system to serve the combined demand flows from the proposed service areas presents several problems. The most difficult of these is the location of a plant. The first site considered was at the far end of the Kittatinny Ridge near the DWGNRA site of Vancampers. The location of a large treatment plant in this area, however, met with objection from the National Park Service, and so a second site at the upper end of the Flat Brook Inlet was chosen.

The development of a collection system to serve the various population centers is relatively easy. The DWGNRA facilities and the residential areas outside the DWGNRA will have little interconnection. All flows from the DWGNRA areas will flow from the south, while residential wastewaters in the upper drainage area of the Little Flat Brook would flow by gravity south to the plant site. The lines collecting from the DWGNRA facilities along the Flat Brook Inlet, on the Flat Brook Peninsula, and from the recreation area of Calno (N.P.S. 29) will include over 45 miles of sewer. Of this, more than 50% will be force main. To accomplish this collection, 64 pumping stations will be required. Although this is a large number of stations, the pumping problem is not as difficult as along the Pocono Plateau in Pennsylvania. This is because the changes in elevation that must be overcome are relatively small. Many of the force mains required will be in the 3" to 6" diameter size, with average daily flows varying from 14 to over 100 gpm. It should be noted that only the DWGNRA facilities will require a major pumping effort to collect its wastewaters. Outside the Recreation Area, little pumping is required.

Development outside the DWGNRA will probably be confined almost exclusively to the narrow valley stretching between the communities of Hainesville and Layton. Most of the permanent and summer residential development in Sandyston Township is expected to be confined to this area.

The Flat Brook Creek drains from Stokes State Forest and High Point State Park, and is not expected to experience extensive growth in permanent population. Summer demands will probably increase as State camping facilities are expanded and new recreational facilities are developed to compliment the National Recreation Area. However, this will represent a relatively small portion of the demand flow in this sub-regional system. Both areas could be served by gravity lines running to the plant site near Peters Valley.

As can be seen in Table H-13, the service population for sub-regional system No. 3 will not increase radically during its 40 year service life. This is because most of the service area is within the National Recreation Area. The flows at the plant, however, will vary greatly with seasons, since in the winter months the DWGNRA flow will decrease to zero, and almost all components of the collection system

TABLE H-13

SUMMARY OF SYSTEM COMPONENTS
ALTERNATIVE III

SUB-REGIONAL SYSTEM NO. 3

Construction Stage	Service Population	Major Sewer Lines (Miles)		Pump Stations		Treatment Plant Average Daily Flow (MGD)	
		Trunk	Sub-Trunk	Major	Minor	Winter	Summer
Phase One (1970-1980)	43,000 (1985)	17	35	17	47	0.7 (1985)	2.4 (1985)
Phase Two (1980-2000)	50,000 (2000)	1	3	0	3	1.2 (2000)	3.1 (2000)
Phase Three (2000-2020)	55,000 (2020)	0	1	0	0	1.5 (2020)	3.6 (2020)
TOTAL		18	39	17	50		

south of the plant will be shut down. The population served will increase from less than 7,000 in the winter of 1985 to over 43,000 in the summer. During the summer of 1985, the DWGNRA demand will be over 58 percent of the total treatment plant capacity required, but by the summer of 2020 this proportion will be reduced to 39 percent.

Sub-regional wastewater system No. 4 - Upper Brodhead area.--

The treatment facility would be located at the confluence of the Brodhead and Analomink Creeks in the northwestern corner of Stroud Township. The sub-regional system would serve all of Barrett, Price and Paradise Townships, Mount Pocono Borough, and the northern fringe of Pocono Township.

This sub-regional system is basically a combination of the two smaller systems described under Alternative II as the Barrett Township and the Paradise Township limited sub-regional systems. Under Alternative III, the plant is moved downstream to the confluence of the two creeks. It also represents a slightly expanded service area.

The major modification of this Alternative III would be the construction of a gravity interceptor from the Canadensis area in Barrett Township south along the course of Brodhead Creek. This line, over 7-1/2 miles in length, would pass through what is now undeveloped country. Sufficient gradient exists to make gravity flow possible. The road which parallels the stream bed could be of limited use as a possible right-of-way.

The population served by this sub-regional system would be slightly greater than Alternative II initially, with some 30,000 summer residents within the service area in 1985. By the year 2020, however, the number of people would be significantly greater with approximately 110,000 served. This is due primarily to the additional development in Price Township and eastern and southern Paradise Township which would probably occur in the final construction stage.

Although this area is not near the National Recreation Area, the fluctuation in flows between winter and summer at the plant will still be large. This is because the region will remain essentially a recreation area for many years to come, and will experience a large influx of summer residents. In Table H-14, it can be seen that most of the building of the system components would occur during the first construction phase prior to 1985, with only the treatment facility going through expansion phases in the future.

Sub-regional wastewater treatment system No. 5 - Lower Brodhead area.--The water pollution control plant would be located at the confluence of the Brodhead Creek and the Delaware River near Minisink Hills, Pennsylvania. The sub-regional system would serve Pocono, Jackson, Hamilton, Stroud, Smithfield, and Middle Smithfield Townships, the Boroughs of Stroudsburg, East Stroudsburg and Delaware Water Gap, plus some DWGNRA facilities in Pennsylvania. The eastern most portion of Chestnut Hill Township would also be served.

TABLE H-14

SUMMARY OF SYSTEM COMPONENTS
ALTERNATIVE III

SUB-REGIONAL SYSTEM NO. 4

Construction Stage	Service Population	Major Sewer Lines (Miles)		Pump Stations		Treatment Plant Average Daily Flow (MGD)	
		Trunk	Sub-Trunk	Major	Minor	Winter	Summer
Phase One (1970-1980)	30,000 (1985)	17	15	2	3	1.2 (1985)	3.0 (1985)
Phase Two (1980-2000)	75,000 (2000)	3	8	0	1	3.0 (2000)	7.5 (2000)
Phase Three (2000-2020)	110,000 (2020)	0	3	0	0	5.0 (2020)	11.0 (2020)
TOTAL		20	26	2	4		

This system would be essentially a combination of the two smaller systems described under Alternative II as the Lower Brodhead and Snydersville systems as well as several other small systems. The major difference under this Alternative is that the development along the entire length of McMichael's Creek drainage basin, reaching from the Stroudsburgs through Hamilton Township and into the upper sub-basin in Chestnut Hill Township would be served.

The addition of these service areas will increase the required plant capacity of the Lower Brodhead Plant to almost 28 mgd by 2020. The initial demand values will be 3.0 mgd in the winter of 1985 and 6.0 mgd in the summer.

The required collection system would grow during each of the construction phases with the bulk of the development occurring during the first and second phases.

As can be seen in Table H-15 nearly 50 percent of the lines and lift stations must be built during the initial construction phase prior to 1980, although only some 60,000 of the ultimate service population of 280,000 people will be present by the year 1985.

Sub-regional wastewater treatment system No. 6 - Paulins Kill area.--The plant would be located at the junction of the Paulins Kill and the Delaware River, east of Columbia, New Jersey. This sub-regional system would serve all of Frankford, Hampton, Lafayette, Stillwater, Hardwick, Blairstown, and Knowlton Townships, plus the Borough of Newton in New Jersey. Portions of Sparta, Andover, Fredon, and Frelinghuysen Townships would also be served.

The sub-regional system considered for the Paulins Kill drainage basin under Alternative III is identical to that considered under Alternative II except that a slightly greater service area can be expected at earlier stages of development. Ultimately, the same system would be developed. One minor consideration, not discussed previously under Alternative II, is the extension of a line across the Delaware River from the Columbia Treatment Plant site into a limited area of Northampton County, Pennsylvania. This is included under construction Phase 3 as a possible extension of service area and would add another estimated 10,000 people to the ultimate service population.

TABLE H-15

SUMMARY OF SYSTEM COMPONENTS
ALTERNATIVE III

SUB-REGIONAL SYSTEM NO. 5

Construction Stage	Service Population	Major Sewer Lines (Miles)		Pump Stations		Treatment Plant Average Daily Flow (MGD)	
		Trunk	Sub-Trunk	Major	Minor	Winter	Summer
Phase One (1970-1980)	60,000 (1985)	25	20	10	6	3.0 (1985)	6.0 (1985)
Phase Two (1980-2000)	170,000 (2000)	15	30	7	4	9.0 (2000)	17.0 (2000)
Phase Three (2000-2020)	280,000 (2020)	12	5	5	3	20.0 (2020)	28.0 (2020)
TOTAL		52	55	22	13		

TABLE H-16

SUMMARY OF SYSTEM COMPONENTS
ALTERNATIVE III

SUB-REGIONAL SYSTEM NO. 6

Construction Stage	Service Population	Major Sewer Lines (Miles)		Pump Stations		Treatment Plant Average Daily Flow (MGD)	
		Trunk	Sub-Trunk	Major	Minor	Winter	Summer
Phase One (1970-1980)	95,000 (1985)	20	25	18	22	4.0 (1985)	9.5 (1985)
Phase Two (1980-2000)	160,000 (2000)	15	65	4	5	10.0 (2000)	16.0 (2000)
Phase Three (2000-2020)	220,000 (2020)	5	15	0	1	17.0 (2020)	24.0 (2020)
TOTAL		40	105	22	28		

Alternative IV - Regional System, Evolved

Description of Alternative IV.--This Alternative is based on the assumption that Alternative III is built through construction Phase 2. Then the six sub-regional systems would be joined to form a single regional system. The central treatment plant site would be below the dam, actually an expanded sub-regional plant No. 5.

The major modifications required to interconnect the sub-regional collection systems, shown on Figure 4, would be as follows:

- a. Force main from Matamoras to Milford.
- b. Force main from Peters Valley (Flatbrook Basin) to Sandyston.
- c. Enlargement of system from Sandyston to Milford to accomodate Flatbrook Basin flow; or, construction of a tunnel crossing below the Reservoir at Sandyston.
- d. Enlargement of Pocono Interceptor and reversal of flow to allow collection of total flow from upper study area south to Lehman.
- e. Interconnection of Pocono Interceptor with trunk line through Marshalls Creek, and enlargement of all main trunk lines and pump stations.
- f. Gravity trunk from sub-regional plant site No. 4 south to upper reaches of sub-regional system No. 5, and enlargement of the trunk line to the plant.
- g. Large force main from Cove (Sulins Kill Basin) north through Water Gap to central treatment plant site.

The incorporation of most of these modifications are discussed under Alternative V. The most significant difference in Alternative IV is that the treatment facilities at five of the six sub-regional plants, amounting to over 43 mgd by 2000, will be abandoned during the third Phase of construction.

Alternative V - Regional System

Description of Alternative V.--Under Alternative V, the assumption was made that discharge of even the most highly treated wastewaters to the reservoir or its tributary streams within the TIRES area is unacceptable and, therefore, all liquid wastes must be carried and treated at some point below the Tocks Island Dam.

Description of System.--The collection system that would serve Westfall Township, Port Jervis, the Town of Deer Park, Matamoras, and upper Montague Township will be the same as that described under sub-regional system No. 1, Alternative III. It would have the same staging of construction. At the south end of the Borough of Matamoras, which has been considered as the site for the water pollution control plant in Alternative III, a pumping station would be built. From here the collected wastewaters would be pumped south to the Borough of Milford some five and a half miles, utilizing the right-of-way of Interstate Highway 84. Because of the variability of flow rates from this upper region (requiring a pumping capacity of less than one mgd to over seventeen mgd during the study period) three force mains of varying sizes would be used to carry the wastewaters south to Milford. If the lines are placed in the shoulder of the Interstate highway, they would be relatively inaccessible, and so all three might logically be placed together in the same trench. Although the largest line would not be used for ten years, it would be easier than excavating again and placing an additional line in the future.

As can be seen from Figure 5, the development of Alternative V can almost be regarded as the interconnection of the six sub-regional plants of Alternative III, discussed under Alternative IV. With a cumulative flow south to the central plant site, however, many system components which previously had been small would now be oversized to accommodate the future flows from the upper regions of the study area. One such component would be the main gravity trunk sewer through the Borough of Milford, into which the force main from Matamoras would discharge. The lift station required at the east end of the Borough to carry the wastewaters across the creek would also be significantly increased. However, the nine miles of major trunk sewer in Milford, Dingman, and Westfall Townships which drain to this point would remain the same as in Alternative III.

The collection system required in Montague Township on the east side of the reservoir would also remain the same as in Alternative III. All lines would discharge into a sump at the New Jersey end of the Delaware River bridge, and then flow by gravity to the Milford pumping station. The only difference would be that the DWGNRA sites south of Montague would not be pumped north but rather would flow south towards Sandyston. Thus, the cumulative flow to the Milford pumping station, located at the site of what had previously been described as the Milford Water Pollution Control plant (Alternative III), would range from less than three million gallons a day in the winter of 1985 to almost twelve million gallons a day by the summer of 2020.

The lines which would be required to carry the collected wastewater from the Milford pump station up onto the Pocono Plateau, then southwest along the Plateau to the Bushkill inlet (22 miles), and then to the plant site 10 miles further down the valley, would be a major component of the system. First construction would require pumping from the Milford Relay Station (elevation 445') south a distance of almost five miles along the plateau, to an elevation of approximately 1,000'. This first increment would require three additional pumping stations as large as the one at Milford. The possibility of skirting along the edge of the reservoir was studied and ruled out since large rock outcrops and the sheer face of the escarpment rising from the water's edge present almost insurmountable natural barriers. A path could be cut along the face of the cliff, but in doing so the natural beauty would be destroyed. The possibility of running the main trunk sewer under water was also considered and discarded, because of both technical and economic weaknesses. An analysis of this concept is discussed in a subsequent section of this report.

As in Alternative III, smaller interceptors running from the small inland drainage basins would join the main line on the Plateau at the crossing of each stream valley. Each one of these low points at stream valleys will require another lifting effort, although the static head would be small. Again, the flows from the inland basins would be supplemented by the discharge of wastewaters from the National Recreation Area sites located along the plateau. Since the route of the trunk line under Alternative V is the same as that under Alternative III, most of the upland DWGNRA sites can still flow by gravity to the main sewer. However, the pumping problem facing the recreation sites located along the water's edge must still be overcome.

The wastewaters from residential and DWGNRA sites in New Jersey substantially alter the cumulative flow total. At this point, a choice in method of collection had to be made. A collection system to service the National Recreation Area sites on the eastern (New Jersey) side of the reservoir could be developed in one of two ways. The densely populated sites of Sandyston, Namanock, and Minisink will have a summer population of about 33,000. The wastewaters from these areas can be collected and pumped north along the reservoir to a point adjacent to the community of Montague Township, as described under Alternative III. This flow could also be reversed and flow south to the N.P.S. site of Sandyston and at that point, cross the river in a reinforced concrete tunnel below the reservoir, to a point near Dingmans Ferry. Since the three recreation areas lie along the water's edge immediately adjacent to such a tunnel, there is logic to this approach.

The collection system serving the lower DWGNRA sites in New Jersey and in the Little Flat Brook basin of Sandyston Township (described under Alternative III as sub-regional system No. 3) could also be collected to this point. This would be accomplished by a force main and gravity line from Peters Valley north over the ridge. It had been considered to interconnect this sub-regional system by pumping to the

east and then to the south, and connect at Culvers Gap with the interceptor that will form a part of the Paulins Kill system. This would have involved a static lift of 480 feet and a total length of line of over four miles instead of the two and one half miles required to interconnect with Sandyston.

With the addition of this wastewater flow (varying from 0.7 mgd in the winter of 1985 to 3.6 mgd by the summer of 2020), the total summer flow at Sandyston by 2020 will be about 4.9 mgd, of which 2.7 mgd will be from DWGNRA sites and 2.2 mgd from outside of DWGNRA.

Referring back to the description of the Pocono Plateau trunk line, the total flow from the upper study area will amount to an average daily summer flow of almost 14 mgd by 2020; this flow will reach a point on the Plateau just west of Dingmans Ferry. Therefore, a choice must be made between collecting north along the New Jersey edge of the reservoir, crossing the bridge, and pumping this additional 4.9 mgd south in the main trunk sewer to the Dingmans Ferry area, or collecting south, crossing in the tunnel, and pumping up the plateau to the same point. Based upon cost comparisons, and other factors, the tunnel crossing was selected.

The ability of the utility tunnel to provide a crossing for other utility lines should be kept in mind. Although the first costs are slightly greater for the tunnel, the multiple purpose aspects of the tunnel crossing and the desire to minimize travel time of wastewaters in the collection system are felt to outweigh the slight savings. Therefore, the tunnel crossing was selected as the best method of connecting the sub-systems under this Alternative.

It should be mentioned here that in addition to these two methods of connecting sub-regional system No. 3, (Flatbrook), other ways of collecting wastewaters from the sub-basin, peninsula and face of the ridge were considered. One approach would involve collecting all wastewaters to the southern most end of the Flat Brook peninsula, and crossing the reservoir in a tunnel to the Bushkill inlet area. This would also involve the crossing of the Flat Brook inlet with an underwater line from the "Kittatinny" areas. The degree of difficulty and higher first cost of this type of system indicate it is not the most efficient solution.

The possibility of tunneling through the Kittatinny Mountain was also considered in lieu of connection with any of the northern or western reaches of the system. The flow would be collected to the southernmost extremity, and there a tunnel would be drilled through the ridge, connecting it with the Paulins Kill interceptor. Preliminary geological investigation, cost analysis, and practical evaluation of the approach have excluded it from further consideration.

Whatever method is selected to connect the wastewater system of the Flatbrook environs with the main system, either by adding it to the

flow crossing the bridge at Milford or crossing the reservoir independently in a tunnel at Dingmans Ferry, the total cumulative summer flow in the Pocono trunk at the crossing of Dingmans Creek will ultimately be over 19 mgd. The pumping effort required to lift the combined flow from the tunnel and the park sites at Dingmans Ferry to this juncture will require another significant pumping effort, with over a mile of dual force main and three lift stations necessary. By the time the trunk reaches the Bushkill inlet, 14 miles further south, another 5 mgd will ultimately be added by the sub-drainage basins in Delaware and Lehman Townships, giving a total demand variation at a point north of Big Bushkill Creek of 4 to 24 mgd between the summer of 1985 and 2020.

From this point, the main trunk would carry down the valley, (roughly paralleling Route U.S. 29), from Bushkill inlet to the community of Marshalls Creek. It should utilize where possible the bed of an abandoned railroad track as a right-of-way. Along the valley, the flow will be augmented by the development of Middle Smithfield Township and additional flows from smaller interceptors extending up the Bushkill and Marshalls Creeks. Winding down the valley of Marshalls Creek to the plant site, this trunk line would deliver a flow of wastewater to the plant varying between 5.5 mgd in the winter of 1985 to 32 mgd in the summer of 2020.

This portion of the collection system under Alternative V represents a major component. The trunk sewer would run a total of over 37.5 miles, from Matamoras to Minisink Hills. The length of time the wastewaters would remain in the lines or wet wells could amount to several days under the most unfavorable conditions, and the initial construction cost alone would run over twenty-six million dollars. While the population served would vary from 250,000 to 400,000 during peak summer periods, it would drop off to 50,000 to 150,000 during winter months.

Under Alternatives IV and V, the wastewaters from several major drainage basins must be carried to the regional plant. Since the plant is situated at the terminus of the Brodhead Creek, the collection system serving this part of the watershed will not be as difficult to develop as the trunk sewers skirting the periphery of the reservoir. The upper sub-basin covering Barrett, Price and Paradise Townships will have the same collection system described under Alternative III as Sub-Regional System No. 4. An additional interceptor would continue from the confluence of the Paradise and Brodhead Creeks down the Lower Brodhead to the plant site. This two miles of new line and seven miles of enlarged line would carry 11 mgd from the upper section and would be added to 22 mgd input through the lower section, giving a total flow to the plant of over 33 mgd by 2020.

The collection system described under Alternative III for the Paulins Kill area would remain the same under this Alternative except that the collected wastewaters would be pumped north from Columbia

through the Delaware Water Gap to the central plant site. As an alternate plant site, the area northeast of Columbia was considered but would require significantly greater volumes of wastewater being pumped. In either case, the building of a force main through the Gap would be a very difficult problem. It should consist of three force mains, ranging in sizes from 14 inches to 54 inches in diameter, laid in the shoulder of Interstate Highway 80, and carried across the Delaware River on the super-structure of the highway bridge. The distance traveled, from a pump station near Columbia to the plant site, would be over 34,000 feet but the static head to be overcome would be relatively small.

The largest component of cost for this connection would be the placement of the lines. If placed in one large trench at the same time, the extensive rock excavation, trenching, rebuilding of the roadbed, and the river crossing would cost approximately \$150.00 per foot. This would give a total capital cost of almost six million dollars to pump the wastewaters from the Paulins Kill to the regional plant site.

The ultimate demand flow represents service to 834,000 summer residents outside the DWGNRA and 138,000 DWGNRA occupants during peak summer periods. The total anticipated service population of 970,000 people represents almost 91% of the summer population present in the study area in the year 2020.

Waste discharges from boats

The danger of pollution from the small boats which will use the reservoir for recreational purposes during the summer months is an important waste disposal consideration. The pollution caused by these water craft varies with location, periods of usage, number of vessels, and type of water body. A variety of studies, however, have shown that the discharge of wastes from water craft causes a significant degree of pollution in receiving streams and lakes.

Various pollution control mechanisms are available for water craft. For small vessels, such as those that would use the reservoir, a holding tank of some type would probably be the most effective mechanism. A holding tank is a closed container for retaining sewage until it can be emptied, usually into on-shore sewage receiving facilities.

The advantages of the holding tank are many. However, there is one major obstacle that must be overcome. Adequate shore facilities to receive, treat, and dispose of the waste from vessel holding tanks are generally not available at existing recreation areas. In each of the alternative systems proposed for liquid waste collection and disposal within the National Recreation Area, the extension of collection facilities to boat marinas has been considered. The wastes from the water craft holding tanks could be discharged to a central collection tank at each launching area, and pumped to the nearest component of the collection system. By providing collection facilities at each marina location, and by strict enforcement of existing and proposed

TABLE H-17
SUMMARY OF SYSTEM COMPONENTS
ALTERNATIVE V

Construction Stage	Average Service Population ¹	Major Sewer Lines(miles)		Pump Stations		Treatment Plant Average Daily Flow(MGD)	
		Trunk	Sub-Trunk	Major	Minor	Winter	Summer
PHASE ONE (1970-1980)	415,000 (1985)	140	130	80	125	14 (1985)	33 (1985)
PHASE TWO (1980-2000)	705,000 (2000)	75	150	25	25	31 (2000)	62 (2000)
PHASE THREE (2000-2020)	970,000 (2020)	30	40	10	10	53 (2020)	89 (2020)
TOTAL		245	320	115	160		

¹ Includes 141,500 from DWGNRA.

state standards to prohibit discharges from vessels, this source of pollution can be virtually eliminated from the Tocks Island Reservoir.

Other methods for pollution control, such as chemical toilets, are much more difficult to regulate than the holding tank concept. Therefore, consideration should be given to prohibiting the use of other disposal methods besides holding tanks.

In order to insure protection of the reservoir from pollution by boat discharges, it is necessary that adequate inspection and policing be provided. Furthermore, as pointed out above, it is critical that waste-receiving facilities be conveniently located at each boat launch site or marina.

SOLID WASTE DISPOSAL

Introduction

The study of solid waste disposal herein was directed towards general predictions of solid waste quantities, formulation of service areas, identification of potential solid waste disposal methods, and preliminary location of solid waste disposal areas. The prime consideration in studies of potential disposal sites and methods was the protection of ground and surface water quality.

Type of disposal system

Various attempts have been made to compare the costs of operating sanitary landfills to the cost of burning rubbish in properly designed incinerators. Landfill costs range from \$0.75 to \$4.50 per ton of waste, depending upon the character of the soil and the ability to provide adequate cover for a suitable sanitary operation. Incinerator studies indicate cost ranges from \$3.50 to \$10.00 per ton for disposal in a modern incinerator plant. The operating cost of future incinerators can be expected to increase as a result of air pollution control requirements now being imposed on incinerator plants. The equipment which will be used in the future will reflect both increased capital investment and increased annual operating costs neither of which can be determined at this time.

It is clear that under difficult landfill conditions, and even under situations where long distance hauling is required, that properly regulated landfill operations can be conducted at great savings over incineration. It must also be considered, when establishing incineration as a practice for a community, that the disposal of noncombustible materials not consumed in the incinerator still requires land disposal sites. Depending upon the character of the waste generated in an area, from 15 to 25 percent of the total waste incinerated will require land disposal. Increased use of aluminum cans, non-refundable bottles, and other packaging materials will substantially increase the materials which cannot be disposed of by incineration.

In addition, a substantial quantity of bulky waste material will develop in the Tocks Island area. Included in this category are junked automobiles, large household appliances, bulky furniture, mattresses, springs and some unburnable types of wastes produced from small industries. Under certain economic conditions associated with large metropolitan areas, the material components are economically salvagable. These materials cannot be economically salvaged in areas distant from large industrial centers. The precise quantities to be expected in relation to population cannot be determined from any data available at this time. In considering the reservation of land for the future the safest course of action now would be to consider that bulky materials will be handled in landfill

sites. In the event that new technologies develop or that economic changes take place which would permit the salvage of such items, the land included for reservation would simply represent a safety factor in the assumptions which have been made for the ultimate land requirement.

Because of the expected nature of solid wastes in the TIRES area and because of significantly lower costs, disposal by sanitary landfill was determined to be the best solution. Landfill operations can be located and properly operated such that ground and surface waters are not contaminated. Furthermore, studies indicate that there is sufficient land available within reasonable distances to allow efficient operation of landfills. Finally, landfill operations are easily adaptable to the anticipated seasonal variation in waste loads in the TIRES area.

Formulation of service zones

Population and therefore the generation of solid wastes are not evenly distributed over the study area now and will not be in the future according to the population projections. The two major population centers will be the regional center of Newton in the Paulins Kill drainage basin and the regional center of the Stroudsburgs in the Brodhead drainage basin. Other population centers in decreasing order of magnitude are: that section of Pike County in the study area, that part of Orange County in the study area, and that part of northern Warren County in the study area.

Because of the uneven distribution of population in the study area, for the purpose of preliminary analysis in the solid wastes study, several approaches had to be studied to resolve the unbalanced distribution of population. This population distribution had to be further analyzed against consideration of solid waste generated by the DWGNRA. The standard factors used herein for determining solid waste service zones are present and future transportation systems, and the proximity to potential final disposal areas.

A cursory investigation of the General Development Plan for the Delaware Water Gap National Recreation Area indicates five major areas where solid waste will be generated:

1. Milford Section: Montague Township, Sussex County, Milford, and Westfall Township, Pike County.
2. Minisink Section: Sandyston and Montague Townships, Sussex County.
3. Dingmans Creek Station: Lehman and Delaware Townships, Pike County.

4. Bushkill Creek Station: Middle Smithfield Township, Monroe County and Lehman Township, Pike County.
5. Kittatinny Section: Blairstown, Hardwick Townships, in Warren County and Stillwater Township in Sussex County.

Three of the five major areas are at the northern end of the DWGNRA. While the solid waste from the Recreation Area seems to be concentrated in one general area, compared to the solid waste from the regional centers it will not be significant. The National Park Service has indicated a preference towards contracting with private collectors to dispose of solid waste from within the DWGNRA. (If private collectors are not available there may be an opportunity to utilize soils with moderate limitations in some sections of the DWGNRA for a landfill operation.) Private collectors should be encouraged to take advantage of this economic opportunity rather than having the National Park Service seek their own solution.

There are ten service areas that can reasonably dispose of all solid wastes within their area at this time. The boundaries of the service areas are not intended to be precise and transportation of the solid waste may require hauls of greater than ten miles. The boundary lines attempt to conform with the boundaries of minor political divisions within the drainage area of the Tocks Island Region Environmental Study.

The service areas are described as follows:

1. Northern Warren - Hardwick, Blairstown, and Knowlton Townships and the greater Portland Borough area in Pennsylvania; also the Water Gap and Kittatinny sections of the DWGNRA.
2. East-Central Sussex - Sparta, Andover, Lafayette Townships and the Town of Newton.
3. West-Central Sussex - Stillwater, Fredon, Hampton, Frankford Townships and Branchville Borough.
4. North-Western Sussex - Sandyston and Montague Townships; also the Milford Section (in part) and the Minisink Section of the DWGNRA; and part of the solid waste from High Point State Park.
5. West Orange - The Towns of Port Jervis and Deerpark.
6. North-Eastern Pike - Westfall and Milford Townships and the Boroughs of Matamoras and Milford. There may not be an acceptable site in this service area; therefore, this area could be combined with the West Orange Service Area.

7. East-Central Pike - Delaware and Dingman Townships and part of Porter, Blooming Grove and Shohola Townships; and the Dingman's Creek section of the DWGNRA.
8. Pike and Monroe - Lehman, Middle Smithfield, and part of Porter Townships; and the Bushkill Creek section of the DWGNRA.
9. Northern Monroe - Barrett, Price, Paradise Townships and Mount Pocono Borough.
10. Southern Monroe - Stroudsburg, East Stroudsburg, and Delaware Water Gap Borough; Smithfield, Stroud, Hamilton, Jackson, and Pocono Townships.

Solid waste generation and disposal has less of a relationship to drainage basins than water supply and liquid waste collection and treatment. Solid waste may be readily transported into or out of given drainage basins but, at this time, there is no significant quantity of solid waste being transported into the study area for disposal and the total quantity of waste going out can be neglected.

Political boundaries may be significant when the collection and/or disposal of solid waste is handled by local governmental units. Private collectors and private disposal sites can and do accept solid wastes from other political subdivisions and other states.

Waste management is ultimately the responsibility of government and the environment can be protected if the public is willing to bear the costs. The uncertain factor is the desire of government to cope with the wastes of society. This is the key element that will determine environmental quality. The open, rural townships that make up the majority of the land area in the TIRES have not, as yet, been faced with the significant solid waste volumes that face urban and suburban regions; however, the projected future growth will generate significant volumes.

The study has not gathered data on, and has not made analysis of, governmental organization for waste management in the TIRES region, nor has the study directly examined in detail the efficiency of present procedures. This task was not within the scope of the assignment, that is, the protection of water quality. However, it is common knowledge that various waste handling and disposal activities are spread among many different units and levels of government each functioning at different degrees of effectiveness.

There are in each service area suitable areas for landfill operations. Specific, limited sites are not recommended.

The choice of service areas has been affected by the type of highway network available in the area and by topography of the area. Some of the controlling features are the Delaware River crossings, mountains, and stream gorges. There will be four major bridges for cross-river access after the completion of the reservoir project: Portland-Columbia Bridge, Delaware Water Gap Bridge, Milford-Montague Bridge, and the two bridges between Port Jervis and Matamoras. There will not be a bridge between the Water Gap and Milford, a distance of some 35 miles.

Culvers Gap provides access between Sandyston Township and the rest of Sussex County, but it would be more reasonable to minimize the transportation of solid waste and locate a landfill site in Montague or Sandyston Townships. The stream gorges and large land ownership patterns in Pike County have discouraged the full development of a primary and secondary road system. Easy movement parallel to the Delaware River is provided only by Rt. 209 (relocated).

Transportation routes and available landfill sites act as stronger determinants than the State boundaries and existing political divisions and other factors that can result in a higher total cost of disposal. Integrated service areas, based upon optimum collection and disposal plans, can probably minimize solid waste disposal costs and thereby present a strong case for solid waste management.

Analysis of potential landfill sites

A preliminary investigation of potential landfill sites was made through an examination of topography, geology, and soil limitations for sanitary landfills in the area. The principal reason for this investigation was to determine possible or probable ground water pollution from a sanitary landfill method of solid waste disposal. This study assumes that trash and garbage is no longer dumped into surface water bodies or onto flood plains causing obvious pollution of the water resources.

A properly located and managed sanitary landfill will not cause the pollution of wells and underground water supplies through leaching (contamination drainage from refuse).

There are, therefore, two significant aspects influencing the potential for a sanitary landfill site:

1. the effect of leachate on the ground water resources, and
2. the availability of soil cover. Proper cover reduces the possibility of health hazards and can keep the site from becoming a blight on the landscape. Landfill areas that have been adequately compacted and covered can be used for parking areas, parks, recreation areas, industrial sites, and many other valuable

uses. The land may be more valuable because of its level, finished condition than before the landfill operation started.

The United States Department of Agriculture, Soil Conservation Service has developed soil limitations criteria for sanitary landfills. Factors considered in rating the limitations for use are seasonal high water table, permeability, slope, depth to bedrock, stoniness, surface texture, and flood hazard. Additional costs of operation are involved to overcome each limitation on any given site, and thereby afford protection to the ground water and to prevent a health hazard. The following table from the Soil Conservation Service lists these limiting factors and indicates the degree of limitation applied to each characteristic of the limitation. The one giving the highest degree of limitation is used to rate the soil as slight, moderate, or severe.

The presence of a soil survey for most of the region simplified the task of evaluating conditions. Two exceptions are northern Monroe County, Pennsylvania and Orange County, New York. Soils interpretations are useful for determining the suitability of sites for a specific use and predicting the type and degree of problems likely to be encountered. They are also helpful in determining the kind and amount of additional on-site investigations that might be needed, thereby permitting adequate soil investigation at minimum cost.

It should be cautioned that suitability ratings, degrees of limitations, and other interpretations are based on the typical soil in each mapping unit. At any specific location on the property, actual conditions may differ from the survey information. On-site investigations will be needed before actual site selections are made. The decision as to whether areas will be used for a specific purpose, regardless of the soil limitations, is not within the scope of this report. Although the areas of suitable soil are presented in this concept plan, they do not indicate specific sites.

In summary, the following general specifications were considered in the final location of a landfill site:

1. Site should be in areas in which surface run-off and ground water will not be affected by contamination.
2. Presently unusable areas such as quarries and gravel pits can be used if protected so that ground water contamination will not occur.
3. The site should be reasonably accessible without undue costs for access roads.
4. Suitable soil conditions and depths to bedrock should be reviewed for economics in operating the disposal site.

TABLE H-18
SOIL LIMITATIONS FOR SANITARY LANDFILLS

Limiting Factor	Degree of Limitation		
	Slight	Moderate	Severe
Depth of seasonal high water table ¹	Deeper than 4' below surface	1-1/2' to 4' below surface	Less than 1-1/2' below surface
Permeability	More than .63"/hr.	.20"/hr. to .63"/hr.	Less than .20"/hr.
Slope	0-8 percent	8-15 percent	15+ percent
Depth to bedrock ²	More than 5'	3 to 5'	Less than 3'
Stoniness	Nonstony to stony	Very stony	Extremely stony to rubble land
Surface soil texture	Sand, loamy sands, sandy loams, loams, silt loams	Silt, clay loam	Silty clay loam, clay, muck, peat
Flood hazard ³	Seldom	Occasional	Frequent

¹Seasonal high water table will prevent proper landfill operations during certain seasons and seepage can cause contaminated liquids to flow out on the lower banks.

²This is depth to hard unrippable bedrock, and on-site investigation should be made to determine actual depth to bedrock.

³This is an estimate of dominate condition, and on-site investigation to determine actual overflow frequency should be made.

5. The availability of cover material for depressed sites which are to be filled should be studied for these locations. However, due consideration should be given to the fact that with modern equipment, earth-moving and transportation of cover material does not unduly influence the cost of waste disposal in landfill sites.

State regulatory measures

The disposal of refuse is regulated by statutory authority in New Jersey, New York and Pennsylvania. In addition to the statutory authority enacted by the States, there are general prohibitions against the disposal of solid waste along highways, on specific lands, or into the waters of the States. Specific application of regulations may arise from the disposal of solid waste material into the classified waters of the State or from air pollution at an open dump, an improperly operated incinerator, or stench from an open dump. The Departments of Agriculture in the three States prohibit almost all feeding of unpasteurized garbage to hogs and poultry. This regulation has curtailed garbage disposal by hog feeding.

In substance, the three States' regulations require that all refuse disposal areas--private and municipal--are to be operated as sanitary landfills. Regulations prohibit the burning of refuse at such sites, discourage salvaging, and require the following:

1. A limited working face at the landfill.
2. Compacting and covering with six inches of cover material daily.
3. Covering with two feet of compacted cover material as final grade is reached.
4. Effective control of rodents, flies, and other insects.
5. Fencing to confine litter.
6. Year-round approach and access road.
7. Approval of new sites by health authorities.

Subject to State regulation, solid waste collection and disposal services and related regulation are a local responsibility. Generally in the three States the County and Municipal enabling legislation contains provisions authorizing units of local government to enact local laws, ordinances, or rules and regulations pertaining to solid waste collection and disposal.

Local regulations may prohibit practices which endanger health or property or which result in nuisances. Such regulations may also

control private collectors in the interest of satisfactory collection and disposal service. This authority usually means the regulation of all or some of the following: use of any lands for dumps, the collection of garbage, the storage of refuse on town highways, and the control of smoke or gases. In addition, most government levels can provide for municipal refuse services and a basic public works organization. Such services may be financed by special service charges or from general revenue.

The TIRES area has examples of all the above. This study has not extensively inquired into all of these levels of local powers and responsibilities, but did ascertain where regulations are in effect that apply to existing disposal methods and sites. Regulations have been more extensively developed in the Newton-Sparta, Stroudsburgs, and Port Jervis regional centers than in the rural townships.

TIRES solid waste program recommendations

This report presents general recommendations designed to improve refuse collection and disposal practices in the study area, to relieve individual municipalities of the problems associated with the operation of their own disposal sites, to achieve substantial savings in refuse disposal costs, and to reduce water pollution, health, sanitation, and air pollution problems. The plan and recommendations are based upon proven refuse disposal methods and newer developments are reviewed for potential future utility.

Except for privately owned and operated facilities that are not controlled by municipal boundaries, there is a tendency for each community to have its own solid waste disposal facility. Unnecessary duplication of equipment and personnel usually results from this practice and many poor operations occur because the municipalities cannot afford to equip, staff, and run them properly. The latter condition has occurred in the study area with the exception of the Sparta Landfill and the Stroudsburg-East Stroudsburg-Stroud Township Landfill.

It is therefore recommended, based upon the service areas, that Joint Regional Refuse Disposal Districts be created to offer service to every municipality in the study area. Within each service area, one or more landfills should be operated so that refuse from the service area's population centers can be hauled directly to the landfill site with a maximum travel of about eight to ten miles. In addition, each municipality within a Joint Regional Refuse Disposal District should adopt a uniform ordinance to assure adequate storage, collection, and disposal of refuse.

The individual municipalities would decide to provide municipal collection or allow private collectors, or a combination of both. Each municipality should require disposal at one of the Joint Regional Refuse Disposal District sites by contract refuse collectors and by residents if personal disposal is permitted.

Rural areas present a special problem because of the high cost of collection. Refuse Collection Stations equipped with approximately eight cubic yard bulk-storage containers or compactor-trailers (one or more as needed) should be strategically located. A person can then dispose of his own refuse in a sanitary manner. The compactor-trailers are simple enough for anyone to operate. It will probably be desirable to construct simple ramps at these stations so that refuse may be unloaded directly from trucks and cars. Logical locations such as crossroads can serve as Collection Stations.

One of the main advantages of this method of rural refuse collection is the ability to expand or reduce the amount of service (number of Collection Stations or containers) as the demand changes with the seasons. Summer residents and weekenders will dispose of refuse even if the method of disposal is unsatisfactory. When a peak flow of refuse is anticipated, an additional collection can be made.

Bulk storage containers might also be located where personal refuse disposal is high, such as at schools, recreation areas, and remote business places. One of the best locations is the highway rest stop where containers could serve the litter conscious visitor who will use the facility if provided.

Refuse Collection Stations should only be a temporary expedient until the density of residential development reaches a sufficient level for house to house collection.

Because there is no easy method of determining who is disposing of rubbish at a Collection Station, or who exactly should be charged, each municipality serviced by a Collection Station should be responsible for the collection and placement of refuse from within its boundaries in the container or containers provided at the Collection Station. The municipality or contractor should service each Collection Station at least twice weekly, more often during the vacation season, transporting the refuse to a specific sanitary landfill.

Equipment is available that makes it possible to collect refuse in large quantities from sparsely populated areas where service by standard refuse collection equipment and a municipal or regional landfill operation are not economically justified. The on-site servicing of large capacity containers makes it possible to collect refuse with a minimum expenditure of time and personnel resources.

Refuse Collection Stations could be located in all or part of the following municipalities in the study area:

NEW JERSEY

Sussex County

Montague Township
Sandyston Township

Warren County

Hardwick Township
Blairstown Township
Frelinghuysen Township
Knowlton Township

PENNSYLVANIA

Monroe County

Price Township
Middle Smithfield Township
Paradise Township
Pocono Township
Coolbaugh Township
Tobyhanna Township
Tunkhannock Township
Chestnuthill Township
Jackson Township
Ross Township
Hamilton Township

Pike County

West Fall Township
Dingman Township
Shohola Township
Blooming Grove Township
Green Township
Porter Township
Delaware Township
Lehman Township

Based on average costs for collection and disposal of waste production in suburban type communities, the following information may be utilized to determine annual per capita costs whether accomplished totally by governmental operations or through contracts to private operators for collection and disposal.

- | | |
|--|--------------------------|
| 1. Average persons per home | 3.5 |
| 2. Annual collection costs per home | \$20 to \$35 per year |
| 3. Average home generation | 2.5 tons per year |
| 4. Average disposal cost - landfill | \$0.75 to \$4.50 per ton |
| 5. Average disposal cost - modern incineration | \$6.00 to \$10 per ton |

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APPENDIX I

COST ESTIMATES AND COST-SENSITIVITY ANALYSES

This appendix contains capital and annual cost estimates for the various systems investigated for water supply and waste disposal in the Tocks Island Region. To facilitate comparison of alternative plans for those systems for which alternatives have been studied, all costs for such alternatives have been converted to present worth (as of 1970). The unit costs used in this study represent average costs prevailing in 1968 and 1969.

Capital costs

Capital costs have been derived for all alternatives studied and for various construction periods assuming staged development. The water-supply costs are presented for two construction periods, from 1970 to 1990 and from 1990 to 2020. Three construction periods were assumed for sewerage alternatives, 1970 to 1980, 1980 to 2000, and 2000 to 2020. For solid-waste disposal, the periods considered were from 1970 to 1990, and 1990 to 2020.

Major facilities, as listed in the tables included in this appendix, were tabulated individually by construction period. To allow consideration of potential economies of scale, unit costs reflecting relative capacities for the facilities were then applied. A subtotal cost was obtained for each period, and a construction contingency of 15 percent was added to arrive at the value shown as "Total Construction Cost." An additional 20 percent of the total construction cost was then taken as an estimate of the "Associated Costs" to cover such items as purchase of land and rights-of-way, engineering design, surveying, construction supervision, legal fees, and bonding costs. The total construction costs and associated costs were added to produce the estimated "Total Project Cost."

The capital costs for water supply and waste disposal systems are presented in various tables included in this appendix.

Annual costs

Average annual costs have been estimated to cover four components: 1) debt service, which is taken herein to include payments of principal and interest; 2) operation and maintenance of treatment facilities--labor, supplies, chemicals, electric power, etc.; 3) operation and maintenance of booster stations and sewer lines--labor, electric power, etc.; and 4) administration. These average costs are presented in various tables for each construction period used in the analyses.

It is realistic to assume that all facilities scheduled for a given construction period will not be built at one time. Rather, construction will be spread over the entire period. Annual costs will

not be constant over a construction period, but will increase with time as bonds are sold to finance construction and as facilities are completed and require operation and maintenance. However, for simplification, it was assumed that construction would be at a constant rate during any one phase. Thus, at the beginning of a construction period, no capital costs would have been incurred for facilities to be built during that period. At the end of the period, all capital costs would have been incurred. The cumulative capital outlays between the two points were assumed to increase at a constant rate.

In the basic computation of annual costs, debt-service costs were derived assuming an interest rate of seven percent and an amortization period of 40 years. It was also assumed that water works and wastewater treatment facilities would require replacement every 40 years. Storage reservoirs, where necessary to provide dry-weather streamflows adequate for dilution of treated effluents, were assumed to have a useful life of 100 years.

Debt-service contingency costs.--To the annual debt-service costs (payments of principal and interest), a surcharge of 25 percent was added to cover contingencies not accounted for elsewhere. Such contingency costs are frequently included in customer rates charged by utilities to meet requirements of financing institutions. The annual costs presented in various tables in this appendix include this 25 percent surcharge.

The basic assumptions of interest rates, amortization periods, and other factors have been subjected to sensitivity tests to determine the effect of significant changes in these factors on the relative costs of alternative systems. These sensitivity tests are discussed later in this appendix.

Average water and wastewater flow rates were determined for each construction period, and unit costs reflecting economies of scale were applied to obtain estimates of annual costs for pumping and treatment in both water-supply and waste-treatment systems. In each case, the debt-service, pumping, and treatment costs were added to obtain a subtotal cost. Then an administrative cost of 20 percent of the subtotal was added to obtain a total annual cost for the system for each year of the construction period.

Water supply

The cost estimates for proposed water-supply systems to serve the Tocks Island Region are presented in Tables I-1 and I-2. Table I-1 shows the total capital outlays for each of several categories of facilities for the two construction periods, from 1970 to 1990, and from 1990 to 2020. This table is based on an assumption that ground water will be developed to meet practically all water-supply demands in the region in the period 1970 through 2020.

TABLE 1-1

CAPITAL COSTS OF WATER SUPPLY SYSTEMS

Development Period (1)	Cost in millions of dollars:								Total Project Cost (10)
	Well Fields (2)	Power Supply (3)	Transmission Facilities (4)	Storage Facilities (5)	Subtotal (6)	Construction Contingency (15 percent) (7)	Total Construction Cost (8)	Associated Costs (20 percent) (9)	
<u>Ground Water</u>									
Stage 1 1970-1990	7.5	2.3	20.6	5.9	36.3	5.5	41.8	8.4	50.2
Stage 2 1990-2020	<u>6.3</u>	<u>0.0</u>	<u>0.9</u>	<u>6.7</u>	<u>13.9</u>	<u>2.1</u>	<u>16.0</u>	<u>3.2</u>	<u>19.2</u>
Subtotal	13.8	2.3	21.5	12.6	50.2	7.6	57.8	11.6	69.4
<u>Surface Water</u>									
<u>Withdrawal Treatment</u>									
Stage 1 1970-1990	0.7	1.2	3.1	0.4	5.4	0.8	6.2	1.3	7.5
Stage 2 1990-2020	<u>1.0</u>	<u>2.3</u>	<u>1.8</u>	<u>1.1</u>	<u>6.2</u>	<u>0.9</u>	<u>7.1</u>	<u>1.4</u>	<u>8.5</u>
Subtotal	<u>1.7</u>	<u>3.5</u>	<u>4.9</u>	<u>1.5</u>	<u>11.6</u>	<u>1.7</u>	<u>13.3</u>	<u>2.7</u>	<u>16.0</u>
TOTAL	15.5	5.8	26.4	14.1	61.8	9.3	71.1	14.3	85.4

*Based on average unit costs prevailing in 1968 and 1969.

TABLE I-2
ESTIMATED AVERAGE ANNUAL COSTS OF WATER SUPPLY DEVELOPMENT

Development Period (1)	Annual cost in millions of dollars									
	Ground Water Development				Surface Water Development					
	Debt Service (2)	Maintenance (3)	Power (4)	Subtotal (5)	Debt Service (6)	Maintenance (7)	Power (8)	Subtotal (9)	Total (10)	
1970-1990	2.38	0.30	0.58	3.26	0.352	0.088	0.210	0.650	3.910	
1990-2020										
Additional	3.26	0.25	0.47	3.98	0.750	0.077	0.030	0.857	4.837	
Total*	5.64	0.55	1.05	7.24	1.102	0.165	0.240	1.507	8.747	

*Total costs shown for second development period include continuing annual costs for facilities constructed during first construction period.

The indicated outlays for surface-water development represent only that area in Pennsylvania along existing Route 209 between East Stroudsburg and the boundary of the National Recreation Area.

Table 1-2 presents estimates of average annual costs for water-supply development in the Tocks Island Region from 1970 to 2020. These annual costs are shown for both ground water and surface water development. They are shown also for the two development periods used in the analysis. The costs of the facilities constructed and operated during the second construction period, 1990 to 2020, will be in addition to the continuing annual costs of those water-supply facilities built during the first period and remaining in service during the second period. Thus, the total costs shown in the last line of Table 1-2 cover the facilities constructed during both periods.

Capital costs.--As shown in Table 1-1, it is estimated that capital expenditures of \$69.4 million for ground water development and \$16.0 million for surface water development would be necessary to meet the projected demands for the period to 2020. The sum of these two amounts, \$85.4 million, represents the minimum cost, assuming full advantage is taken of the generally abundant ground water resources in the region. However, if the decision is made, for whatever reason, to develop more surface supplies and fewer ground water supplies, the total capital costs will probably be greater. For example, in a separate study reported elsewhere, it was shown that a surface water supply adequate to meet the 2020 needs of the Borough of Delaware Water Gap would cost \$24,200 per year, whereas an adequate ground water supply would cost only \$4,300 per year.

Annual costs.--The annual costs for water supply, as shown in Table 1-2, are estimated to average about \$3.9 million during the period from 1970 to 1990. This average annual amount would be expected to approximate the actual annual cost for the year 1980, in the middle of the 20-year period. The actual cost would be less than the average amount for those years preceding 1980, and greater for years after 1980.

The costs shown in Tables 1-1 and 1-2 are those estimated for public and semi-public water-supply systems. The semi-public systems would include those providing water for private developments that serve the public, such as resorts, hotels, motels, and shopping centers. Private wells serving single households or small commercial enterprises, such as automobile service stations and restaurants, are not included.

Liquid-waste disposal

Estimates of costs for disposal of liquid wastes in the Tocks Island Region are presented in Tables 1-3 through 1-18. The estimates given include capital outlays, average annual costs, and present worth (as of 1970).

Capital costs.--For the five alternative sewerage plans studied, capital outlays have been derived for each of three construction periods covering the next half-century. The first period covers the decade from 1970 to 1980, the second period is from 1980 to 2000, and the third is from 2000 to 2020.

Table I-3 presents estimates of capital costs for sewerage alternative I, which calls for 116 small local wastewater treatment plants. Similar estimates of capital outlays for the other four alternatives investigated are shown in Tables I-4 through I-7. In these tables, capital costs are shown separately for the Delaware Water Gap National Recreation Area and the rest of the study area.

All sewerage alternatives are based on an assumption of a high degree of wastewater treatment, including 95 percent removal of biochemical oxygen demand and removal of substantially all phosphates. The costs listed in Tables I-3 through I-7 do not include intracommunity sewerage costs, nor do these tables show the costs of facilities needed for dilution of treated effluents.

Annual costs.--The capital outlays for the five sewerage alternatives have been converted into estimated average annual costs. The results are presented in Tables I-8 through I-12. These tables show, for each alternative plan, the average annual costs for each of the three development periods. The annual costs are categorized as 1) debt service; 2) treatment; 3) pumping, and 4) administration. These costs are shown first for the assumption that no Federal or State grant would be available to help defray the cost to the users of the sewerage facilities. Next, in recognition of established financial assistance programs, the costs to the users are shown after taking into account reductions by grants of 30 and 60 percent, respectively, of the total capital outlays.

The annual costs of sewerage alternatives for the second development period include debt service costs remaining from the first period. Similarly, the annual costs shown for the third period include debt service on capital outlays from both the first and second periods. The cost estimates in Tables I-8 through I-12 do not include those costs allocated to the National Recreation Area.

Table I-13 presents estimates of average annual costs allocated to the DWGNRA for the five alternative sewerage schemes and for the three development periods.

Dilution costs

Even for the assumed high degree of treatment, the quality of water in the streams receiving the treated effluents will depend on the amount of dilution by clean water in the streams. For some alternative sewerage schemes studied, the effluent from many treatment plants would be discharged to streams not having sufficient streamflow at all times to provide adequate dilution. Therefore, in order

TABLE 1-3

ESTIMATED CAPITAL COST FOR WASTEWATER COLLECTION AND TREATMENT
ALTERNATIVE 1--MULTIPLE SMALL SYSTEMS

Development Period (1)	Cost in millions of dollars						
	Treatment Plants (2)	Sewer Lines* (3)	Pumping Stations (4)	Subtotal (5)	Construction Contingency (15 percent) (6)	Total Construction Cost (7)	Associated Cost (8)
							Total Project Cost (9)
1970 to 1980 Non-DWGNRA	25.6	12.7	1.1	39.4	5.9	45.3	9.0
DWGNRA	7.5	3.2	1.1	11.8	1.8	13.6	2.7
1980 to 2000 Non-DWGNRA	22.5	14.9	1.4	38.8	5.8	44.6	8.9
2000 to 2020 Non-DWGNRA	5.5	1.3	0.2	7.0	1.1	8.1	1.6
TOTAL	61.1	32.1	3.8	97.0	14.6	111.6	22.2
							133.8

#Costs of intra-community sewers are not included.

TABLE 1-4

ESTIMATED CAPITAL COST FOR WASTEWATER COLLECTION AND TREATMENT
ALTERNATIVE 11--LIMITED SUBREGIONAL SYSTEMS

Development Period (1)	Cost in millions of dollars							
	Treatment Plants (2)	Sewer Lines* (3)	Pumping Stations (4)	Subtotal (5)	Construction Contingency (15 percent) (6)	Total Construction Cost (7)	Associated Cost (8)	Total Project Cost (9)
1970 to 1980 Non-DWGNRA	11.2	22.0	8.4	41.6	6.2	47.8	9.6	57.4
DWGNRA	5.9	7.4	3.1	16.4	2.5	18.9	3.8	22.7
1980 to 2000 Non-DWGNRA	24.6	26.5	3.8	54.9	8.2	63.1	12.6	75.7
2000 to 2020 Non-DWGNRA	7.8	6.1	0.4	14.3	2.1	16.4	3.3	19.7
TOTAL	49.5	62.0	15.7	127.2	19.0	146.2	29.3	175.5

*Costs of intra-community sewers are not included.

TABLE I -5

ESTIMATED CAPITAL COST FOR WASTEWATER COLLECTION AND TREATMENT
ALTERNATIVE III--SUBREGIONAL SYSTEMS

Development Period (1)	Cost in millions of dollars						
	Treatment Plants (2)	Sewer Lines* (3)	Pumping Stations (4)	Subtotal (5)	Construction Contingency (15 percent) (6)	Total Construction Cost (7)	Total Project Cost (9)
1970 to 1980 Non-DWGNRA	14.9	24.8	9.5	49.2	7.4	56.6	67.9
DWGNRA	2.4	9.2	6.6	18.2	2.7	20.9	25.1
1980 to 2000 Non-DWGNRA	14.7	26.2	4.2	45.1	6.8	51.9	62.3
2000 to 2020 Non-DWGNRA	14.5	7.2	1.9	23.6	3.5	27.1	32.5
TOTAL	46.5	67.4	22.2	136.1	20.4	156.5	187.8

*Costs of intra-community sewers are not included.

TABLE 1-6
ESTIMATED CAPITAL COST FOR WASTEWATER COLLECTION AND TREATMENT
ALTERNATIVE IV--SUBREGIONAL SYSTEMS UNTIL 2000; THEN ONE REGIONAL SYSTEM

Development Period (1)	Cost in millions of dollars						
	Treatment Plants (2)	Sewer Lines# (3)	Pumping Stations (4)	Subtotal (5)	Construction Contingency (15 percent) (6)	Total Construction Cost (7)	Associated Cost (8)
							Total Project Cost (9)
1970 to 1980 Non-DWGNRA	14.9	24.8	9.5	49.2	7.4	56.6	11.3
DWGNRA	2.4	9.2	6.6	18.2	2.7	20.9	4.2
1980 to 2000 Non-DWGNRA	14.7	26.2	4.2	45.1	6.8	51.9	10.4
2000 to 2020 Non-DWGNRA	23.7	31.2	8.0	62.9	9.4	72.3	4.5
DWGNRA	1.3	4.0	1.4	6.7	1.0	7.7	1.5
TOTAL	57.0	95.4	29.7	182.1	27.3	209.4	41.9
							251.3

#Costs of intra-community sewers are not included.

TABLE 1-7
ESTIMATED CAPITAL COST FOR WASTEWATER COLLECTION AND TREATMENT
ALTERNATIVE V--REGIONAL SYSTEM

Development Period (1)	Cost in millions of dollars						
	Treatment Plants (2)	Sewer Lines* (3)	Pumping Stations (4)	Subtotal (5)	Construction Contingency (15 percent) (6)	Total Construction Cost (7)	Associated Cost (8)
							Total Project Cost (9)
1970 to 1980 Non-DWGNRA	9.6	46.7	16.9	73.2	11.0	84.2	16.8
DWGNRA	22.4	15.1	7.3	24.8	3.7	28.5	5.7
1980 to 2000 Non-DWGNRA	6.7	31.9	4.4	43.0	6.5	49.5	9.9
2000 to 2020 Non-DWGNRA	13.8	8.7	1.8	24.3	3.6	27.9	5.6
TOTAL	32.5	102.4	30.4	165.3	24.8	190.1	38.0
							228.1
							33.5
							59.4
							34.2
							101.0

*Costs of intra-community sewers are not included.

TABLE I-8

ESTIMATED AVERAGE ANNUAL COST FOR
WASTEWATER COLLECTION¹ AND TREATMENT
ALTERNATIVE 1--MULTIPLE SMALL SYSTEMS

	Annual Costs, Millions of Dollars ²		
	Period 1 (1970-1980)	Period 2 (1980-2000)	Period 3 (2000-2020)
<u>NO GRANT</u>			
Debt Service	2.5	7.6	10.6
Treatment	0.9	1.7	2.0
Pumping	0.1	0.1	0.1
Subtotal	<u>3.5</u>	<u>8.4</u>	<u>12.7</u>
Administrative	<u>0.9</u>	<u>1.7</u>	<u>1.9</u>
Total Annual Cost	4.4	10.1	14.6
<u>30% GRANT</u>			
Debt Service	1.9	5.7	8.0
Treatment	0.9	1.7	2.0
Pumping	0.1	0.1	0.1
Subtotal	<u>2.9</u>	<u>7.5</u>	<u>10.1</u>
Administrative	<u>0.9</u>	<u>1.7</u>	<u>1.9</u>
Total Annual Cost	3.8	9.2	12.0
<u>60% GRANT</u>			
Debt Service	1.3	3.8	5.3
Treatment	0.9	1.7	2.0
Pumping	0.1	0.1	0.1
Subtotal	<u>2.3</u>	<u>5.6</u>	<u>7.4</u>
Administrative	<u>0.9</u>	<u>1.7</u>	<u>1.9</u>
Total Annual Cost	3.2	7.3	9.3

¹Costs of intra-community sewers are not included.

²Excluding costs for DWGNRA.

TABLE 1-9

ESTIMATED AVERAGE ANNUAL COST FOR
WASTEWATER COLLECTION¹ AND TREATMENT
ALTERNATIVE 11--LIMITED SUBREGIONAL SYSTEMS

	Annual Costs, Millions of Dollars ²		
	Period 1 (1970-1980)	Period 2 (1980-2000)	Period 3 (2000-2020)
<u>NO GRANT</u>			
Debt Service	2.7	8.9	13.7
Treatment	0.3	1.1	1.6
Pumping	0.2	0.3	0.5
Subtotal	<u>3.2</u>	<u>10.3</u>	<u>15.8</u>
Administrative	<u>0.8</u>	<u>2.0</u>	<u>2.3</u>
Total Annual Cost	4.0	12.3	18.1
<u>30% GRANT</u>			
Debt Service	2.0	6.7	10.0
Treatment	0.3	1.1	1.6
Pumping	0.2	0.3	0.5
Subtotal	<u>2.5</u>	<u>8.1</u>	<u>12.1</u>
Administrative	<u>0.8</u>	<u>2.0</u>	<u>2.3</u>
Total Annual Cost	3.3	10.1	14.4
<u>60% GRANT</u>			
Debt Service	1.3	4.5	6.7
Treatment	0.3	1.1	1.6
Pumping	0.2	0.3	0.5
Subtotal	<u>1.8</u>	<u>5.9</u>	<u>8.8</u>
Administrative	<u>0.8</u>	<u>2.0</u>	<u>2.3</u>
Total Annual Cost	2.6	7.9	11.1

¹Costs of intra-community sewers are not included.

²Excluding costs for DWGNRA.

TABLE I-10

ESTIMATED AVERAGE ANNUAL COST FOR
WASTEWATER COLLECTION¹ AND TREATMENT
ALTERNATIVE III--SUBREGIONAL SYSTEMS

	Annual Costs, Millions of Dollars ²		
	Period 1 (1970-1980)	Period 2 (1980-2000)	Period 3 (2000-2020)
<u>NO GRANT</u>			
Debt Service	3.2	9.3	13.7
Treatment	0.4	0.9	1.4
Pumping	0.3	0.4	0.8
Subtotal	<u>3.9</u>	<u>10.6</u>	<u>15.9</u>
Administrative	<u>1.0</u>	<u>1.9</u>	<u>2.5</u>
Total Annual Cost	4.9	12.5	18.4
<u>30% GRANT</u>			
Debt Service	2.4	7.0	10.3
Treatment	0.4	0.9	1.4
Pumping	0.3	0.4	0.8
Subtotal	<u>3.1</u>	<u>8.3</u>	<u>12.5</u>
Administrative	<u>1.0</u>	<u>1.9</u>	<u>2.5</u>
Total Annual Cost	4.1	10.2	15.0
<u>60% GRANT</u>			
Debt Service	1.6	4.6	6.9
Treatment	0.4	0.9	1.4
Pumping	0.3	0.4	0.8
Subtotal	<u>2.3</u>	<u>5.9</u>	<u>9.1</u>
Administrative	<u>1.0</u>	<u>1.9</u>	<u>2.5</u>
Total Annual Cost	3.3	7.8	11.6

¹Costs of intra-community sewers are not included.

²Excluding costs for DWGNRA.

TABLE I-11

ESTIMATED AVERAGE ANNUAL COST FOR
WASTEWATER COLLECTION¹ AND TREATMENT
ALTERNATIVE IV--SUBREGIONAL SYSTEMS UNTIL 2000;
THEN ONE REGIONAL SYSTEM

	Annual Costs, Millions of Dollars ²		
	Period 1 (1970-1980)	Period 2 (1980-2000)	Period 3 (2000-2020)
<u>NO GRANT</u>			
Debt Service	3.2	9.3	16.3
Treatment	0.4	0.9	0.9
Pumping	0.3	0.4	0.9
Subtotal	<u>3.9</u>	<u>10.6</u>	<u>18.1</u>
Administrative	<u>1.0</u>	<u>1.9</u>	<u>3.1</u>
Total Annual Cost	4.9	12.5	21.2
<u>30% GRANT</u>			
Debt Service	2.4	7.0	12.2
Treatment	0.4	0.9	0.9
Pumping	0.3	0.4	0.9
Subtotal	<u>3.1</u>	<u>8.3</u>	<u>14.0</u>
Administrative	<u>1.0</u>	<u>1.9</u>	<u>3.1</u>
Total Annual Cost	4.1	10.2	17.1
<u>60% GRANT</u>			
Debt Service	1.6	4.6	8.1
Treatment	0.4	0.9	0.9
Pumping	0.3	0.4	0.9
Subtotal	<u>2.3</u>	<u>5.9</u>	<u>9.9</u>
Administrative	<u>1.0</u>	<u>1.9</u>	<u>3.1</u>
Total Annual Cost	3.3	7.8	13.0

¹Costs of intra-community sewers are not included.

²Excluding costs for DWGNRA.

TABLE I-12

ESTIMATED AVERAGE ANNUAL COST FOR
WASTEWATER COLLECTION¹ AND TREATMENT
ALTERNATIVE V--REGIONAL SYSTEM

	Annual Costs, Millions of Dollars ²		
	Period 1 (1970-1980)	Period 2 (1980-2000)	Period 3 (2000-2020)
<u>NO GRANT</u>			
Debt Service	4.7	12.3	16.6
Treatment	0.3	0.6	0.9
Pumping	0.3	0.6	0.9
Subtotal	5.3	13.5	18.4
Administrative	1.4	2.3	2.8
Total Annual Cost	6.7	15.8	21.2
<u>30% GRANT</u>			
Debt Service	3.5	9.2	12.4
Treatment	0.3	0.6	0.9
Pumping	0.3	0.6	0.9
Subtotal	4.1	10.4	14.2
Administrative	1.4	2.3	2.8
Total Annual Cost	5.5	12.7	17.0
<u>60% GRANT</u>			
Debt Service	2.4	6.1	8.3
Treatment	0.3	0.6	0.9
Pumping	0.3	0.6	0.9
Subtotal	3.0	7.3	10.1
Administrative	1.4	2.3	2.8
Total Annual Cost	4.4	9.6	12.9

¹Costs of intra-community sewers are not included.
²Excluding costs for DWGNRA.

TABLE I-13

ESTIMATED AVERAGE ANNUAL COSTS ALLOCATED TO DWGNRA FOR
WASTEWATER COLLECTION AND TREATMENT

	<u>Period 1</u> <u>(1970-1980)</u>	<u>Annual Costs</u> <u>Period 2</u> <u>(1980-2000)</u>	<u>Period 3</u> <u>(2000-2020)</u>
<u>Alternative I</u>			
Debt Service	\$1,525,000	\$1,525,000	\$1,525,000
Treatment	100,000	100,000	100,000
Pumping	<u>17,000</u>	<u>17,000</u>	<u>17,000</u>
Total Annual Cost	\$1,642,000	\$1,642,000	\$1,642,000
<u>Alternative II</u>			
Debt Service	\$2,120,000	\$2,120,000	\$2,120,000
Treatment	80,000	80,000	80,000
Pumping	<u>38,000</u>	<u>38,000</u>	<u>38,000</u>
Total Annual Cost	\$2,238,000	\$2,238,000	\$2,238,000
<u>Alternative III</u>			
Debt Service	\$2,360,000	\$2,360,000	\$2,360,000
Treatment	50,000	50,000	50,000
Pumping	<u>200,000</u>	<u>140,000</u>	<u>80,000</u>
Total Annual Cost	\$2,580,000	\$2,580,000	\$2,580,000
<u>Alternative IV</u>			
Debt Service	\$2,360,000	\$2,360,000	\$2,790,000
Treatment	50,000	50,000	50,000
Pumping	<u>200,000</u>	<u>200,000</u>	<u>200,000</u>
Total Annual Cost	\$2,610,000	\$2,610,000	\$3,040,000
<u>Alternative V</u>			
Debt Service	\$3,210,000	\$3,210,000	\$3,210,000
Treatment	50,000	50,000	50,000
Pumping	<u>170,000</u>	<u>140,000</u>	<u>100,000</u>
Total Annual Cost	\$3,430,000	\$3,430,000	\$3,430,000

to present valid cost comparisons, it is necessary to evaluate the costs of providing low-flow augmentation for the various alternatives. This has been done, and the estimated costs are presented in Table I-14, in terms of present worth (as of 1970).

The dilution costs are computed on the assumption that flow augmentation would be provided as necessary to maintain streamflows equal to three times the flow of treated effluent. The degree of treatment was assumed to be 95 percent removal of BOD and substantially complete removal of phosphates. The average recurrence interval of streamflows less than the desired flow was assumed to be 20 years. This means that in one year out of twenty, on the average, the dilution flows would be less than three times the effluent flow at some locations at some time during the year. This was assumed to be an acceptable degree of risk of inadequate dilution. For a greater risk, the dilution costs would be less, and, conversely, the risk could be decreased by providing, at greater cost, augmented streamflows with a longer recurrence interval between short periods of inadequate dilution.

The dilution costs decrease with the degree of regionalization. This is because the more regionalized systems would discharge the treated effluents to relatively large streams in which dilution will be adequate with little or no low-flow augmentation.

Water-quality surveillance costs

A cost variable not usually considered in studies of sewerage alternatives is that related to different surveillance requirements for protection of water quality in streams receiving effluents from waste treatment plants. Surveillance needs and costs are related more or less directly to the number of waste discharge points--with more discharges, more monitoring of instream quality is needed. These needs have been translated into estimates of costs for the sewerage alternatives studied. The cost estimates for surveillance are presented in Table I-15.

As shown in the table, surveillance costs decrease as the degree of regionalization increases. For example, Alternative I costs for surveillance for the period from 1970 to 2020 are estimated to have a present worth of 5.48 millions of dollars (discounted to 1970), while Alternative V would result in surveillance costs with a present worth (1970) of only 1.51 millions of dollars. For the intermediate degrees of regionalization called for by Alternatives II, III, and IV, the costs of monitoring stream water quality would fall between these extremes.

On-site disposal costs

The various sewerage alternatives investigated would not serve the same number of persons. Those not served by the public systems would have to depend on septic tanks or other on-site systems serving

TABLE 1-14
ESTIMATED COSTS FOR DILUTION OF TREATED EFFLUENTS

<u>Sewerage Alternative</u>	Cost, Millions of Dollars (Present worth, 1970 ¹)		
	<u>Construction</u>	<u>Operation and Maintenance</u>	<u>Total</u>
I	3.31	1.01	4.32
II	1.48	0.47	1.95
III	0.10	0.03	0.13
IV	0.00	0.00	0.00
V	0.00	0.00	0.00

¹Discounted at 5.0 percent.

TABLE 1-15
STREAM WATER QUALITY SURVEILLANCE COSTS, 1970 to 2020

Sewerage Alternative	Surveillance cost, millions of dollars			
	Average Annual			Present Worth (1970) ¹
	1970-1980	1980-2000	2000-2020	
(1)	(2)	(3)	(4)	(5)
I	0.225	0.265	0.290	4.58
II	0.150	0.200	0.200	3.26
III	0.140	0.140	0.140	2.56
IV	0.140	0.140	0.140	2.56
V	0.070	0.070	0.070	1.28

¹ Discounted at 5.0 percent.

individual households and small commercial developments. The variability of population served by the public sewerage schemes results in a variation of on-site disposal costs, and therefore of total costs, among the alternatives.

This variable cost is analyzed in Table I-16. This table indicates that Alternative I, which would leave unsewered a 2020 peak summer population of about 266,000, would require on-site disposal facilities costing about 126 millions of dollars, in terms of present (1970) worth, for construction and maintenance through the year 2020. Alternative IV, with a smaller unsewered population, would call for an estimated 50-year cost of only about 82 million dollars in terms of present (1970) worth for on-site disposal. The indicated potential savings of 44 million dollars as a result of eliminating many on-site disposal systems would offset much of the cost of the regional system envisioned in Alternative IV. Other sewerage alternatives would require onsite disposal expenditures between those projected for Alternatives I and IV.

Present worth

Because the annual costs of the various alternatives do not take into account the time value of money, they are difficult to compare with respect to cost effectiveness. In order to provide easy and direct comparison of two or more cost series having different outlay patterns over time, it is necessary to reduce each series to a single value at a given time. For financial comparison, the appropriate method of reduction is to discount all costs for a given alternative over the period in question to a specific time and then to add them. The resulting sum is the specific-time value of the costs that are actually to be spread over a significantly long period. If discounted to the present, the specific-time value is usually referred to as the "present worth" of the future costs. In simple terms, the present worth of future costs can be interpreted as the money that must be invested now at compound interest to provide the money needed to pay the future costs as they come due. In this study, all cost series have been converted to present worth (as of 1970) for comparison. The results are presented in Table I-17 for the basic assumptions regarding interest rate, amortization period, useful life of facilities, and population served. Later, the sensitivity of the resulting costs to different assumptions for these factors is analyzed.

It should be pointed out that the discount rate used in computing the present worth of costs presented in Table I-17 was 5.0 percent, whereas an equivalent interest rate of about 8.8 percent was used in calculating the annual cost of wastewater collection and treatment facilities presented in Tables I-8 through I-12. As will be shown later herein, the choice of the least-cost alternative sewerage scheme is not sensitive to the discount rate used to compute present worth, at least within the range of discount rates from 4.0 to 5.0 percent, but is affected if the discount rate is increased to 7.0 percent.

TABLE 1-16

ONSITE DISPOSAL COSTS, 1970 to 2020

Sewerage Alternative	Cost, millions of dollars			Present Worth (1970) ¹
	Average Annual			
	1970-1980	1980-2000	2000-2020	
(1)	(2)	(3)	(4)	(5)
I	6.37	6.99	8.11	126.11
II	6.37	6.32	6.28	115.66
III	5.56	3.95	3.91	84.48
IV	5.56	3.95	3.04	81.97
V	5.46	4.29	3.18	84.16

¹ Discounted at 5.0 percent.

As shown in Table I-17, when all costs of disposing of sewage and maintaining water quality are counted, the plan calling for subregional sewerage systems (Alternative III) is the least-cost alternative. This means that on the basis of economics alone, sewerage regionalization at least to the degree called for under Alternative III is justified. Factors other than costs support this finding, and if these other factors tend to guide a choice other than Alternative III, it will be in the direction of greater regionalization rather than less.

Sensitivity analyses

It was recognized that most of the assumptions used in computing the costs of sewerage alternatives are subject to error. For this reason, sensitivity analyses were carried out to determine the effect of errors, within a reasonable range, in these assumptions. In these analyses, the objective was to show whether the economic choice among the sewerage alternatives would shift from Alternative III to one of the other plans as a result of a change in one or more of the basic assumptions used.

Basic assumptions.--The basic assumptions used to derive the total costs shown in Table I-17, and the changed assumptions used in the sensitivity analyses are as follows:

<u>Factor</u>	<u>Basic value</u>	<u>Sensitivity-test value(s)</u>
Interest (discount) rate, percent.	5.0	4.0
Sewer replacement interval, years.	40	100
Period over which annual costs are considered and discounted to 1970.	1970 to 2020	1970 to infinity
Population projection.	Medium	(High (Low
Level of on-site disposal costs.	Medium	(High (Low

For each of the sensitivity-test values listed above, the total costs for each of the sewerage alternatives were recomputed. Only one factor was changed for each sensitivity analysis; that is, all factors other than the one being tested were held at the "basic values" originally assumed.

The results of the sensitivity analyses are shown in Table I-18. Columns 2 and 3 compare total costs for different interest rates. Columns 4 and 5 show the effect of changing the assumption regarding

TABLE I-17

PRESENT WORTH OF WATER QUALITY MAINTENANCE COSTS
FOR ALTERNATIVE SEWERAGE PLANS, 1970 to 2020
(Based on medium population projections; interest at 5 percent¹.)

Cost Item (1)	Present Worth of Costs, millions of dollars				
	Alt. I (Multiple Small Systems) (2)	Alt. II (Limited Subregional Systems) (3)	Alt. III (Subregional Systems) (4)	Alt. IV (Subregional Systems Until 2000; Then One Regional System) (5)	Alt. V (Regional System) (6)
Construction (40-year Replacement)					
Intracommunity Collection System	68.17	75.51	91.49	92.64	89.76
Extracommunity Interceptors, Pumps, Treatment	76.07	92.17	98.77	103.30	131.73
Operation and Maintenance, Extracommunity	52.63	48.32	50.79	51.36	55.11
Storage for Effluent Dilution (100-year Replacement)	4.33	1.95	0.13	0.00	0.00
Water Quality Surveillance	<u>4.58</u>	<u>3.26</u>	<u>2.56</u>	<u>2.56</u>	<u>1.28</u>
Subtotal (Public Costs)	205.78	221.21	243.74	249.86	277.88
Onsite Disposal (25-year Replacement)	<u>126.11</u>	<u>115.66</u>	<u>84.48</u>	<u>81.97</u>	<u>84.16</u>
TOTAL	331.89	336.87	328.22	331.83	362.04

¹Recalculation of present worth at a 7 percent discount rate changes the rank order of the various alternatives. On the 7 percent basis, Alternative I would have a slightly lower present worth value than Alternative III.

Table I-18

COMPARISON OF WATER QUALITY MAINTENANCE COSTS
FOR DIFFERENT ASSUMED PARAMETERS
(SENSITIVITY ANALYSES)

Present Worth (1970) of Total Water Quality Maintenance Costs,
Millions of Dollars

Alternate Plan Number and Description (1)	For Interest Rate of		For Sewer Replacement Interval of	
	5%	4%	40 years	100 years
	(2)	(3)	(4)	(5)
I--(116 Local Systems)	331.89	374.51	331.89	317.01
II--(25 Local and 8 Subregional Systems)	336.87	380.01	336.87	319.99
III--(6 Subregional Systems)	<u>328.22</u>	<u>367.76</u>	<u>328.22</u>	<u>308.52</u>
IV--(6 Subregional Systems Until 2020; Then 1 Regional System)	331.83	372.51	331.83	313.98
V--(1 Regional System)	362.04	403.23	362.04	338.50
<u>Other Parameters</u>				
Replacement Interval:				
Sewers, Interceptors:	40 years	40 years	40 years	100 years
Pumps, Treatment Works:	40 years	40 years	40 years	40 years
Dilution Storage Reservoirs:	100 years	100 years	100 years	100 years
Period Over Which Annual Costs Are Considered and Discounted to 1970:	1970 to 2020		1970 to 2020	
Interest Rate	5%	5%	5%	5%
Population Projection	Medium	Medium	Medium	Medium
Level of Onsite Disposal Costs	Medium	Medium	Medium	Medium

For Indicated Period Over Which Annual Costs Are Considered and Discounted to 1970		For Indicated Population Projection			For Indicated Level of Onsite Disposal Costs		
1970 to 2020	1970 to Infinity	Low	Medium	High	Low	Medium	High
(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
331.89	389.22	275.47	331.89	389.64	<u>300.36</u>	331.89	363.42
336.87	396.63	277.18	336.87	395.38	307.96	336.87	365.79
<u>328.22</u>	<u>387.8</u>	<u>272.58</u>	<u>328.22</u>	<u>384.26</u>	307.10	<u>328.22</u>	<u>349.34</u>
331.83	395.95	274.29	331.83	391.66	311.34	331.83	352.32
362.04	423.15	306.03	362.04	417.98	341.00	362.04	383.08

Assumed Values

40 years	40 years	40 years	40 years	40 years	40 years	40 years	40 years
40 years	40 years	40 years	40 years	40 years	40 years	40 years	40 years
100 years	100 years	100 years	100 years	100 years	100 years	100 years	100 years
1970 to 2020	1970 to Infinity	1970 to 2020			1970 to 2020		
5%	5%	5%	5%	5%	5%	5%	5%
Medium	Medium	Low	Medium	High	Medium	Medium	Medium
Medium	Medium	Medium	Medium	Medium	Low	Medium	High

Notes:

Columns 2, 4, 6, 9, and 12 are identical, and represent the basic assumptions and costs against which the other assumptions and costs in each set are compared.

the useful life of trunk sewers and interceptors. The differing costs in columns 6 and 7 reflect different periods of analysis over which annual costs are taken into account and discounted to present worth; column-6 values are for the 50-year period from 1970 to 2020, and column-7 shows the present worth of annual costs from 1970 to infinity. Columns 8 through 10 compare costs based on low and high population projections with the costs resulting from the basic assumption (medium projection). The last three columns show the effects on total costs of low and high assumptions regarding the costs of installing and maintaining onsite systems for disposal of liquid wastes.

These analyses show two important effects of varying assumptions. The first is the effect on total costs of each alternative sewerage scheme. The second is the effect on the selection of the least-cost alternative. For purposes of this feasibility investigation, the second effect is the most important, as it indicates the degree of probability that a selection made today on the basis of least cost would remain the best selection in future years if projections and assumptions prove to be inaccurate.

In each set of total costs shown in Table I-18, the least cost is underlined. It is noteworthy that in only one of the seven sensitivity tests, did the change in the basic assumption result in a change in the least-cost alternative plan. The assumption of low on-site disposal costs, instead of medium costs, shifted the least-cost choice from Alternative III to Alternative I. After the completion of the sensitivity tests, it became evident that general interest rates had risen significantly. A supplementary check was then made with a 7 percent discount rate, with the other basic assumptions unchanged. This also indicated Alternative I as having the lowest present worth; however at 7 percent discount and the high level of on-site disposal cost, Alternative III once again is the least-cost approach. Even with the exceptions cited, the sensitivity analyses support a high degree of confidence that the subregional system (Alternative III) is the economic choice for wastewater disposal.

The finding that relatively low costs for on-site disposal would influence the economic choice among sewerage alternatives forces further consideration of on-site disposal costs. If the low value assumed for the sensitivity test could be shown to be reasonable, it would leave in doubt, at least from the economic standpoint, any decision to regionalize sewerage beyond that degree of regionalization called for in Alternative I. For this reason, the on-site disposal costs have been subjected to further study.

Such further study has clearly indicated that the assumption of low costs for on-site disposal systems is not reasonable. More regulation of the installation and maintenance of on-site septic tank systems can be expected, and it will be stricter than at present. Such increased regulation has already been enacted in the TIRES area: the Sewage Facilities Act, in Pennsylvania; and the Critical Sewerage Areas

Act, in New Jersey. This new legislation and other legislation expected to come, coupled with more stringent follow-up, will tend to increase the unit costs of on-site systems. This makes it extremely unlikely that the average on-site disposal costs would be as low as 25 percent under the basic cost estimate (the medium value) in any future period.

Furthermore, there are other significant considerations concerning on-site septic tank systems besides the cost of the system itself. These externalities involve expenditures, and these have not been included in the estimates in this study of the average costs of on-site septic tank systems. For instance, there is the distinct possibility of the transmission of disease as a result of septic tanks effluent entering ground water that is used (or is projected for future use) as a source of drinking water. This externality has particular applicability in the TIRES area, where much of the future drinking water supply is expected to come from ground-water sources. Septic tank effluent can also find its way into surface waters, often within a few hours. The likelihood of pollution is a danger in many locations in the TIRES area, where a rapid population growth dependent upon on-site-septic systems could saturate completely the capacity of soils to assimilate wastes. Surface and ground-water pollution can be the result.

The existence of such external costs implies that if they were included in the estimates of average costs of on-site septic tank systems, the costs would exceed even our high estimates--and might even justify extension of sewer service into areas not previously considered feasible in the more regionalized approaches. The magnitude of these external costs, and the objective to maintain the high-quality environment of the Tocks Island Region, leads us to conclude that it is undesirable to be satisfied with the limited degree of regionalization called for in Alternative I, and that the sensitivity analyses are not the only factors that should be considered in evaluating this alternative. In other words, even if the assumption of low on-site disposal costs is valid, which would result in Alternative I becoming the least-cost choice, there are external costs to be considered--and they are significant.

Solid-waste disposal

Estimates of costs for disposal of solid wastes in the Tocks Island Region are presented in Tables I-19 and I-20. The estimates given include capital outlays and average annual costs, and are based on the assumption that all solid-waste disposal for the region will be by the sanitary landfill method using land within the region. Alternative methods of disposal were considered, but were ruled out because of greater cost. For example, transportation of solid wastes

to landfill sites outside the region would entail costs similar to those for landfill within the region, plus significant increased costs for hauling. Incineration for reduction of waste volume would reduce the volume of wastes for final disposal, but the cost of incineration would be significantly greater than the savings resulting from the reduced landfill requirements.

Capital costs.--The capital cost estimates include land acquisition, site development, and equipment. Because of the possible extreme variation, from site to site, of landfill costs, the estimates must be considered as approximate only. The degree of possible variation depends upon land costs and site development (grading, access roads to site, access to cover material, etc.). Contingencies have been included in the unit values used in the analysis.

TABLE I-19
ESTIMATED CAPITAL COSTS FOR SOLID-WASTE
DISPOSAL BY SANITARY LANDFILL
(Costs in millions of dollars)

<u>Development Period</u>	<u>Costs</u>
1970 to 1990	12.8
1990 to 2020	<u>22.4</u>
Total	35.2

Annual costs.--Annual costs of solid waste disposal can also vary significantly depending upon site layout, site topography, availability of cover material, etc. Therefore, the values presented in Table I-20 must also be considered approximate only.

TABLE I-20
ESTIMATED AVERAGE ANNUAL COSTS FOR SOLID-WASTE
DISPOSAL BY SANITARY LANDFILL
(All costs in millions of dollars)

<u>Development Period</u>	<u>Debt Service</u>	<u>Operation and Maintenance</u>	<u>Total</u>
1970-1990	0.6	0.8	1.4
1990-2020	1.65	3.9	5.55